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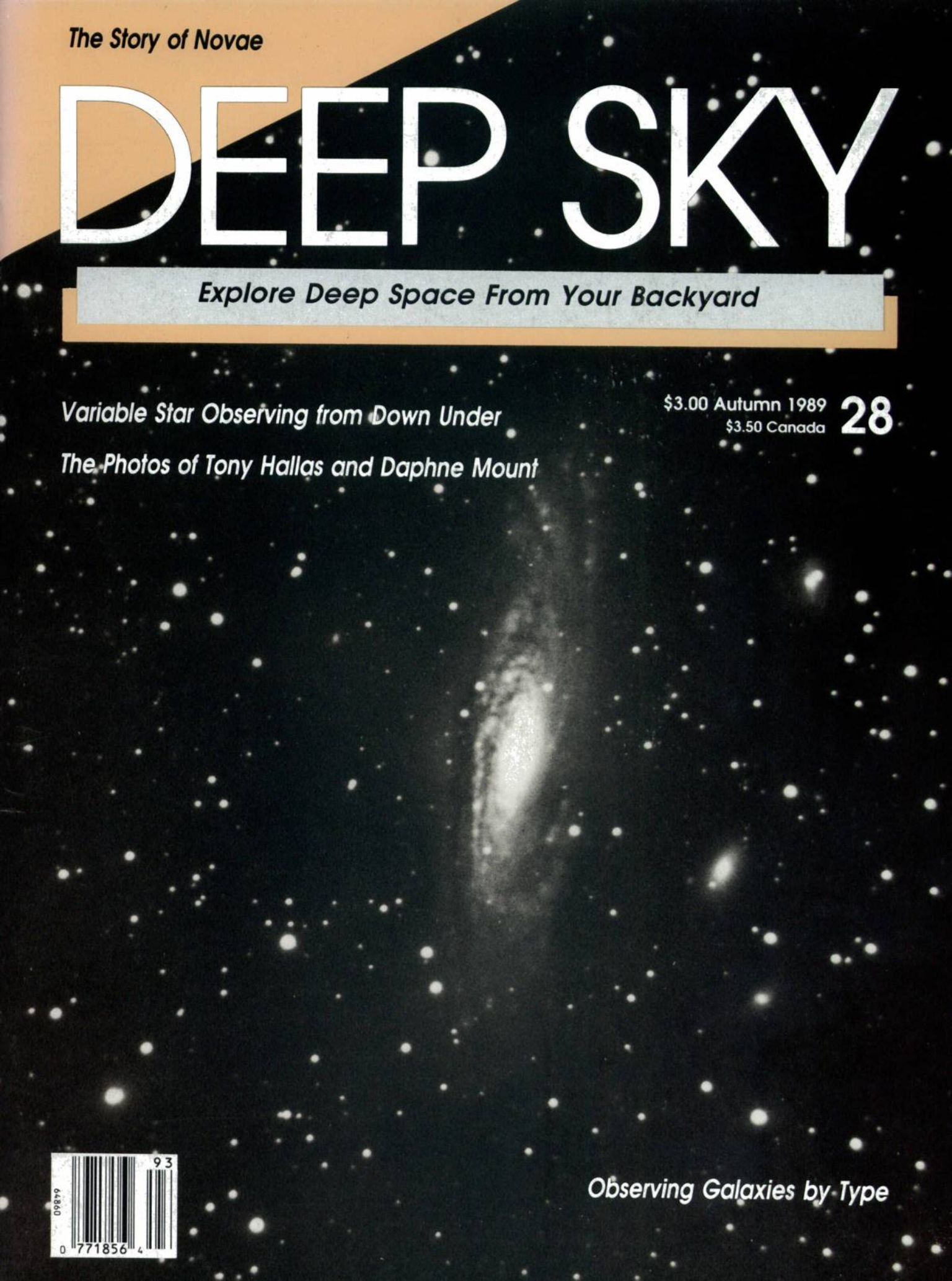

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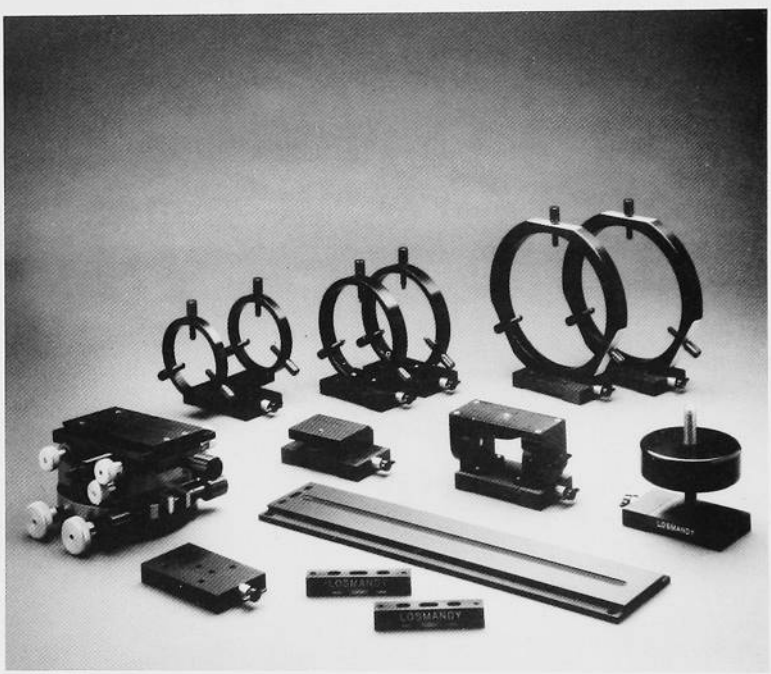

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DEEP SKY

THE MAGAZINE FOR DEEP-SKY OBSERVERS AND ASTROPHOTOGRAPHERS AUTUMN 1989 VOLUME 7, NUMBER 4

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by Alan Goldstein
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The *Uppsala General Catalogue* and its Place in History
by David Higgins
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Observing Variable Stars from Down Under
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Opposite page: The M101 field in Ursa Major photographed by Tony Hallas and Daphne Mount with a 300mm lens, hypered Tech Pan, and a 60-minute exposure.

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At the Eyepiece
A Universe of Galaxies

Galaxies rule the world of deep-sky observing. More than any other type of object, they offer endless variations of shape, brightness, structure, and size when viewed with medium and large telescopes. Numerically, they far exceed any other class of nonstellar object — in all, some 10,000 specimens are visible in backyard scopes.

But what do we really see when we look at galaxies? We've all heard the standing jokes about how all deep-sky objects, galaxies included, appear as indiscriminate blobs of light. Is that all we're seeing? In its most boiled-down, primeval form, is deep-sky observing simply a parlor game of finding the objects without really *seeing* them?

In his extensive article beginning on page 10, Alan Goldstein argues to the contrary. Goldstein, founder of the National Deep Sky Observer's Society, shows that moderate and large telescopes are capable of revealing enough detail in galaxies to invite an educated guess at the galaxy's morphological type.

By carefully viewing the brightness of a galaxy's nucleus, the surface brightness of its halo, the characteristics of its arms,and dark matter in its environs, it's possible to assemble a basic profile of many galaxies at the eyepiece. After reading Goldstein's article, tramp outside with pencil and pad in hand. Make a survey of some of the galaxies described in the article, and then view and make notes for some not included in the piece. Later, you can check a reference to see how well you did in determining the types of galaxies that softly greet you in the eyepiece.

Other features this issue include David Higgins' description of the *Uppsala General Catalogue of Galaxies*.. This article surveys the *UGC* and its place in the scheme of things and provides examples from that famous compilation. Following that piece is an article by Australian variable star observer Peter Williams, which outlines his adventures with observing variables in the land down under.

Let me say that I was very pleased to meet many readers at this year's Stellafane convention last August in Springfield, Vermont. It's a great privilege for me to talk with you, see what's on your minds, and find out what you want to see more of. We almost got rained out (echoes of last spring's TSP!), but thankfully the drips stopped at noon on Saturday and we had a delightful afternoon. I am looking forward to talking with more of you at Astrofest in Kankakee, Illinois, this September.

One last thing: the editors of *Deep Sky* are encouraged by the response to our book, *Deep Sky Observing with Small Telescopes*. However, some of you still didn't listen to my plea from the last issue. To help our editors sleep soundly these nights, we need every single one of you to order this book immediately. The book is filled with information, photos, and sketches, and costs less than dinner for two (unless you go to McDonald's). We don't want you to miss out on the first printing, and enough people were involved with this project that it should be easy to find one somewhere, walking along a road or something, and have him sign it. Have I convinced you? There — feel better now?

Dave Eicher
Editor-in-Chief

Letters to *Deep Sky*
Arizona Database Available

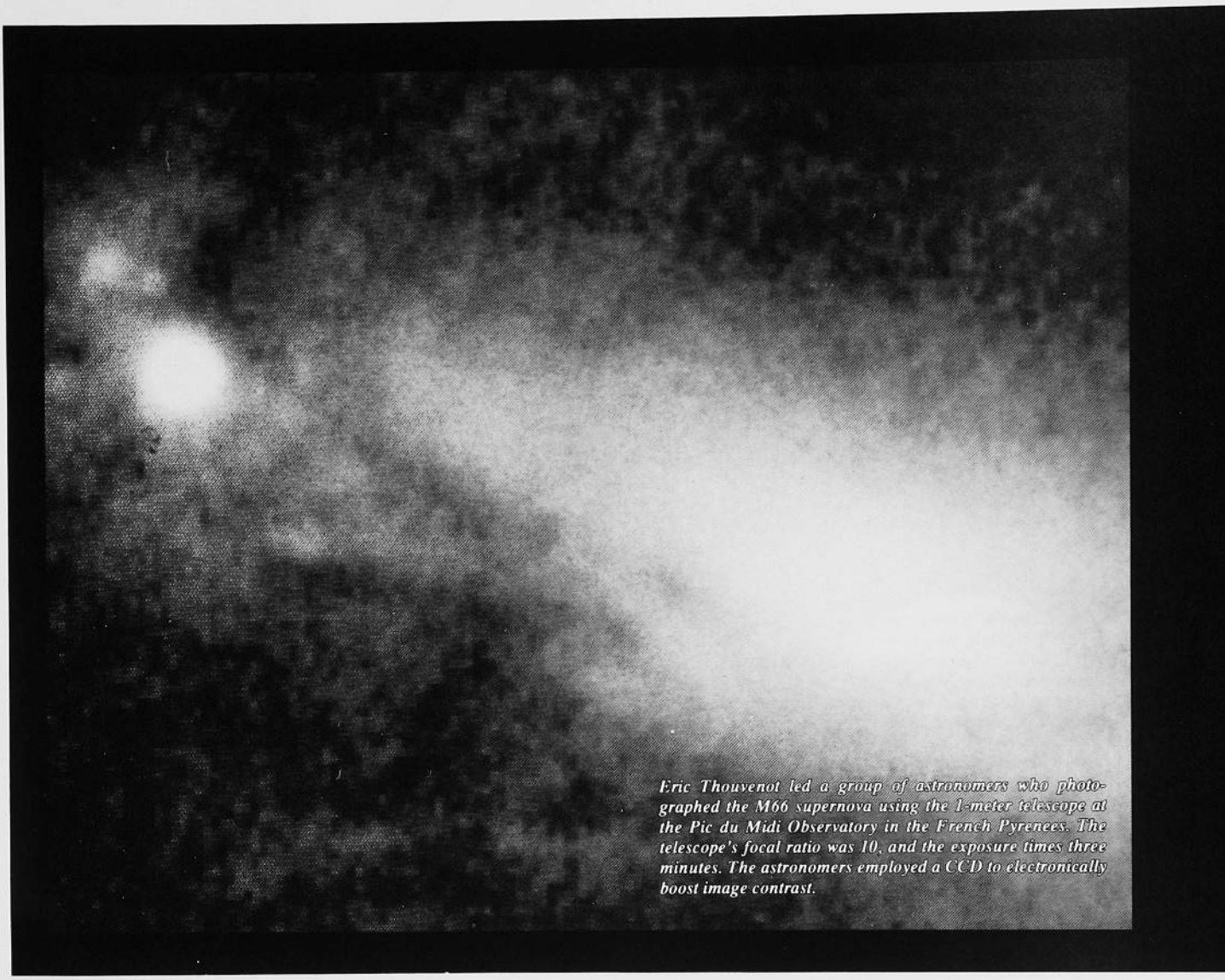
Arizona Database Available
Dear Dave / The Saguaro Astronomy Club of Phoenix is proud to announce that Version 5.0 of its deep-sky database is ready for distribution. With a great deal of help, club members have finished checking the data on some 10,300 objects included on the floppy disks. We have gleaned information from such sources as *Sky Catalogue 2000.0*, the *Uppsala General Catalogue of Galaxies*, *Burnham's Celestial Handbook*, the *Perek-Kohoutek* catalog of planetary nebulae, *NGC 2000.0*, the Webb Society handbooks, and *Deep Sky* magazine. The file is well over two megabytes in size, and a hard disk is recommended for using it. A program included with the database allows users to search through the data for specific information.

A network has been established to help distribute the data to anyone who wants a copy. To prevent any single person from being swamped, we have divided up the distribution among four people. Additionally, the database has been uploaded to CompuServe, and our club is anxious to get the disks in the hands of BBS operators willing to make the disks available on their BBS.

To obtain a copy of the database, send two 360K IBM formatted DOS diskettes in a postage-paid disk mailer to the address below that is nearest to you. Please make certain that you include sufficient postage on the return mailer. The database is in ASCII format delimited with a double quote and is archived to keep the disk space down. A program to unarchive the data is included on the disk. Macintosh users can obtain a copy by sending two 800K disks to Glen Sanner.

A complete list of database contributors is included on the disk. We want especially to thank Brian Skiff, Jack Marling, Steve Gottlieb, Harold Corwin, Jim Lucyk, and Alister Ling for their assistance in making Version 5.0 as error free as possible. If you use the database

This year's bright supernova in M66 (1989B) was discovered last winter by Robert Evans of Hazelbrook, New South Wales. Kim Zussman's photograph shows the supernova as it appeared on February 11, 1989. Zussman used an 11-inch f/10 SCT, hypered Tech Pan, and a 40-minute exposure.



Eric Thouvenot led a group of astronomers who photographed the M66 supernova using the 1-meter telescope at the Pic du Midi Observatory in the French Pyrenees. The telescope's focal ratio was 10, and the exposure times three minutes. The astronomers employed a CCD to electronically boost image contrast.

and find an error, please let us know.

The MS/DOS distributors are: Steve Coe (see address below); Alister Ling, 1017 Seneca Avenue #310, Mississauga, Ontario L5G 3X5 Canada; and Jim Barclay, P.O. Box 40, Manly, Queensland, Australia 4179. The Macintosh distributor is Glen Sanner, P.O. Box 35, Natrona Heights, PA 15065.

Steve Coe
5942 West Loma Lane
Glendale, AZ 85302

The Rise of Refractors

Dear Dave / It was a pleasure to meet you at AstroFest II in Hartford on March 18. I enjoyed your talk on deep-sky observing and agree with you that refractors are making a comeback in astronomy, particularly the apochromatic refractors from Roland Christen of Astro-Physics. I have worked with several of these refractors over the past four years and have found that they provide excellent deep-sky images. My interest in apochromats began after reading Richard Berry's article in *Deep Sky #5* (Winter 1983). In this article Berry discussed the importance of low internal scattering, excellent optics, high image contrast, and a wide field of view.

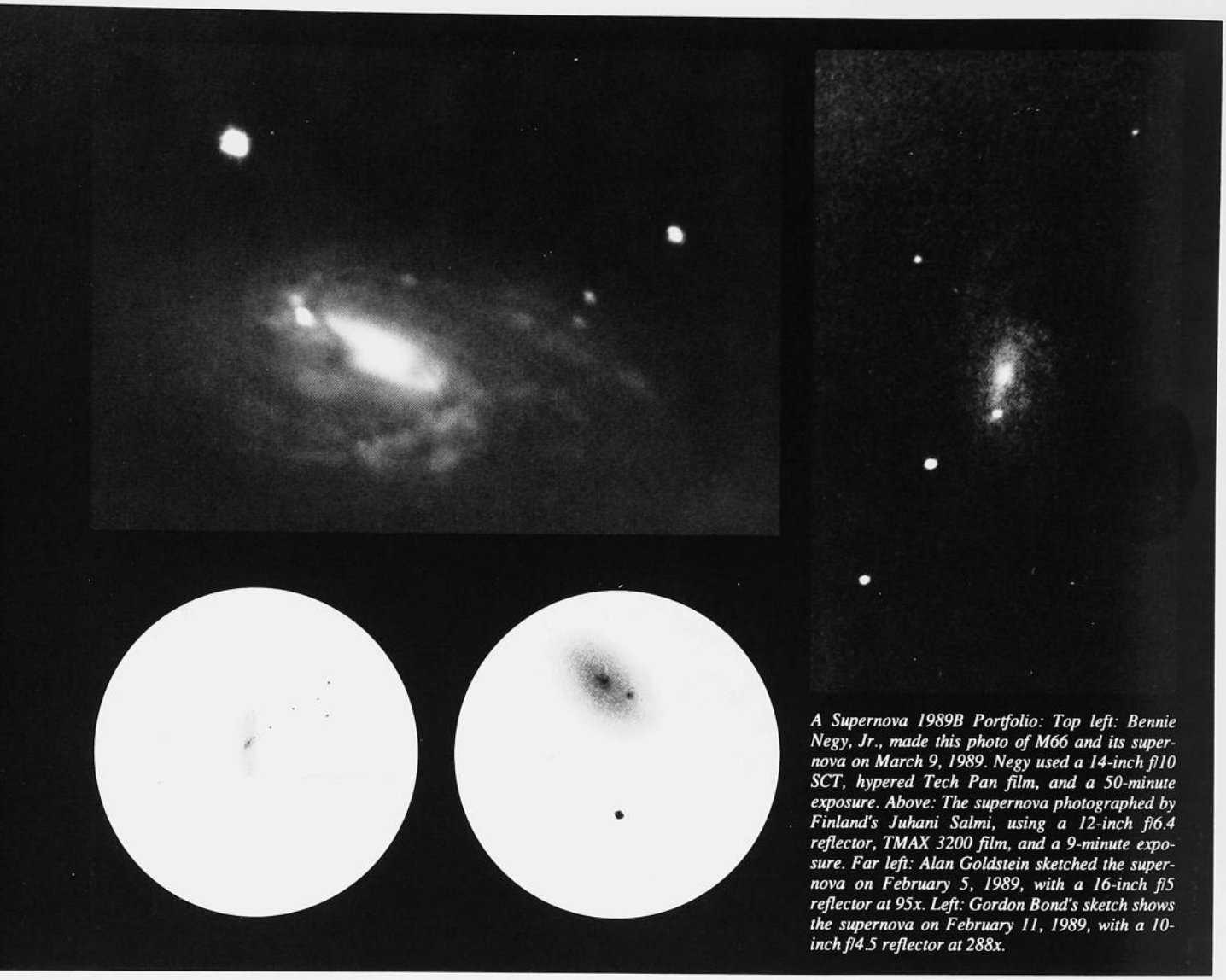
The first refractor I worked with was a 4-inch f/6 from Astro-Physics, which gave sharp, contrasty views over a wide field. One night while using this telescope under the dark, rural skies of upstate New York, I was surprised by how well it showed M51. The nuclei of both M51 and NGC 5195, the satellite galaxy, appeared starlike, and it was possible to see the connecting arm between the two. Also, I noticed some dark rifts around the central portion of M51. Undoubtedly the dark, transparent skies helped bring out this kind of detail, but it was still quite impressive for a 4-inch scope.

A year later I moved up to a 6-inch f/9 apochromat. With this telescope I first noticed the "cirrus effect" in M42, first described by John Herschel. In his January 1987 column in *Sky & Telescope*, Walter Scott Houston related Herschel's comments comparing the Orion Nebula to "the breaking up of a mackeral sky when the clouds of which it consists begin to assume a cirrus appearance." Further, through this telescope, the nebula had more of a bluish tint than the usual greenish tint I've normally observed. One dark, transparent night I noticed a reddish tint along the southern rim of the nebula. I've observed M42 many times with a variety of telescopes since 1974 and only on one other occasion have I observed color other than the standard greenish tint. Using a 14.5-inch scope on an exceptionally clear evening, I spotted some pink tones along the southern rim.

Last year I purchased a 6.8-inch f/14 apochromatic lens in a cell and constructed a tube assembly for it. The resolution of this long-focus lens is quite good. I can routinely split six stars in the Trapezium with it.

I enjoy reading your magazine, Dave, and wish you continued success.

Eric Bunn
178 Main Street
Westford, MA 01886



A Supernova 1989B Portfolio: Top left: Bennie Negy, Jr., made this photo of M66 and its supernova on March 9, 1989. Negy used a 14-inch f/10 SCT, hypered Tech Pan film, and a 50-minute exposure. Above: The supernova photographed by Finland's Juhani Salmi, using a 12-inch f/6.4 reflector, TMAX 3200 film, and a 9-minute exposure. Far left: Alan Goldstein sketched the supernova on February 5, 1989, with a 16-inch f/5 reflector at 95x. Left: Gordon Bond's sketch shows the supernova on February 11, 1989, with a 10-inch f/4.5 reflector at 288x.

Fast Star near the Whirlpool

Dear Sir / One cloudy evening while looking at the March 1989 ASTRONOMY, I noticed a funny thing regarding the M51 photo on page 79. Comparing this photo with the cover of volume one of *Burnham's Celestial Handbook* and with the photo on page 9 of the Spring *Deep Sky*, I noticed a tiny shift in one of the stars in front of the galaxy. The star in question is a 13th-magnitude object about 5' southwest of the galaxy's center. The star lies about 3' south-southwest of the 12th-magnitude star that lies in front of the galaxy's bright spiral arm. Very close to the mystery star a 15th-magnitude lies star just to the north. About 50" southeast of the mystery star lies a stellar association or an H II region. Using this H II region as a reference point, the motion of the mystery star is quite plain.

My curiosity aroused, I dug up all the M51 photos I could find in my small astro-library and began a detailed examination. One photograph from an old book issued by Belgrade Observatory showed the galaxy photographed with the 60-inch telescope at Mount Wilson in 1910. Comparing this photo with the *Burnham's* cover — which was made with the 200-inch Hale telescope — and the recent 14-inch SCT photo from the March ASTRONOMY, the star's shifting is obvious. I deduced that as time progresses, the star's proper motion is carrying it in a west-southwest direction. In the Mount Wilson photo the star lies on the outer rim of an inside spiral arm division. In the Hale photo the star is in the gap between the two spiral arms. In the 14-inch shot the star has moved into another spiral arm division.

In the March ASTRONOMY Alan Goldstein stated that the 12th-magnitude star lies about 2' southwest of M51's nucleus. On the *Burnham's* cover the separation between this star and the nucleus is about 24mm. This gave a scale of 1mm = 5". Thus, the star's shifting between 1910 and 1988 is approximately 4mm, or 20", in p.a. 245°. If we divide this by 78 years, we get an approximate annual proper motion of 0.25".

The April 1988 issue of ASTRONOMY has a color photo of M51 on page 100 that shows the mystery star as a yellowish object. My suspicion is that this star is moving at a high rate of speed toward the north galactic pole. Could it be that this star is a very distant K-type giant, a member of the population II halo stars orbiting our Galaxy?

Miro Ilic
Iva Vojnovica 48.
Dubrovnik 50000
Yugoslavia

Dear Sir / Due to the relatively late arrival of ASTRONOMY in the bookshops of Australia, the phenomenon which I am about to discuss may have been commented upon by your less-distant deep-sky fans. Comparing the photograph of M51 in the March 1989 ASTRONOMY to one in *Burnham's Celestial Handbook*, it became apparent that a star had changed its position relative to the gal-

axy and to other foreground stars. The star in question is 106.5mm from the left edge and 78mm from the lower edge of the ASTRONOMY print. The motion is not inconsiderable and is readily apparent to the eye. This provides a fine example of the proper motion of a galactic star.

Paddy K. McGee
6 Parson's Grove
Park Holme
Adelaide
South Australia 5043

Don't Swap Those Sketches

Dear Sir / For three years I thought that I was the proud owner of the best 10-inch Newtonian in existence. I was told by an expert that the 2-inch-thick Pyrex mirror was the best he had seen. The collimation was perfect. What more could a man want?

Now I have to get rid of it. You see, in the Winter 1988/1989 edition of *Deep Sky*, you showed two sketches — one of the Omega Nebula and one of the Lagoon Nebula. Oh, shock, horror! My perfect scope is, indeed, useless. You see in my scope the Lagoon Nebula looks like your sketch of the Omega Nebula and the Omega Nebula looks like your sketch of the Lagoon Nebula. Confusing, isn't it?

Seriously, apart from this slight hiccup — anyone can transpose a caption — *Deep Sky* is a fabulous magazine and it reflects the many hours of hard work your writers and editors must do to research their studies. Keep up the good work.

John J. Reddington
33 McKinna Road
Christie Downs
South Australia 5164

Messier Madness

Dear Dave / I recently obtained the Spring issue of *Deep Sky* and would like to comment on the article about the Messier Marathon. I read the article with interest because I was always puzzled why anyone would get involved in such a race. However, the article only reinforced my earlier belief that it is a waste of time to pursue such an effort.

Before I had a decent mount, I often became frustrated at not being able to find objects and found myself wasting time while I could have been observing. After I obtained an accurate equatorial mount, I was astonished at how easy it was to find objects using the setting circles after the mount was properly aligned with the polar axis. I was able to simply "dial-in" objects and found that my observing frustration level had decreased an order of magnitude compared to not using setting circles.

Why the Messier Marathon is advertised as a challenge and setting circles cannot be used is beyond me. I fail to see how such a race can improve observing skills, considering that the use of a 1° field eyepiece is recommended as an aid and a chart is provided, indicating how far to sweep the telescope before the next object appears in the eyepiece.

The whole idea of a Messier Marathon is completely opposite to the satisfaction one gets from observing deep-sky objects. I hope that not too many amateurs will get tangled up in this Messier Madness!

G. Jan de Vries
445 Vermont Avenue
Berkeley, CA 94707

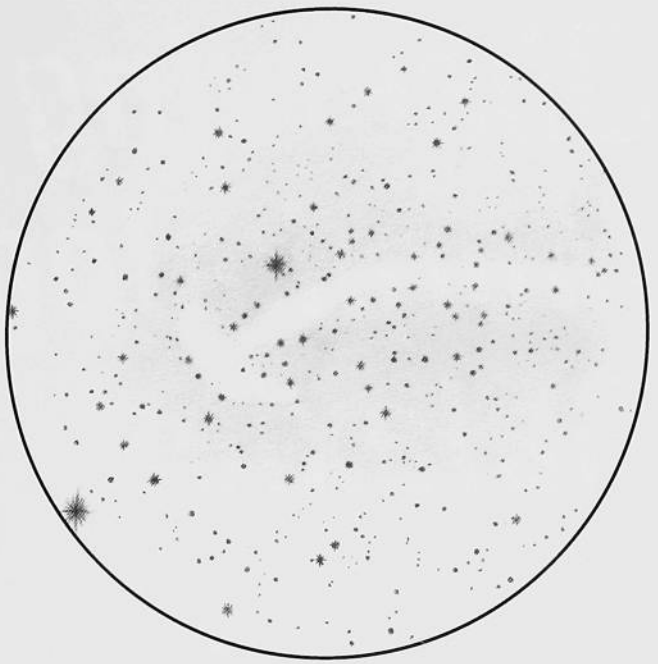
M66 Supernova Photos from Finland

Dear Mr. Eicher / I think you will be interested in these photos of the new supernova in M66, discovered visually by Robert Evans. I am including two prints taken with Kodak T Max 3200 speed film, a 12-inch f/6.4 Newtonian, and a 9-minute exposure. Seeing was not terrifically good. Visually, I saw the supernova easily with my telescope, positioned some 50" north of the galaxy's center.

Juhani Salmi
JS Observatory
Irjanpolku 8
15500 Lahti
Finland

Thompson's Mystery Object

Dear Dave / I have another mystery object for your readers. This one is considered by some observers to be the finest telescopic open cluster in the sky. Even though it is bright enough to be easily visible to the naked eye, it is, amazingly, not very well known.



Australian Gregg Thompson sketched a rich area of the southern Milky Way that he offers as a mystery object. Can anyone identify it? Thompson writes the area contains a "rich cluster bright enough to be visible to the naked eye, yet, amazingly, not very well known." A 12.5-inch telescope shows over 200 stars in this cluster, which has superposed on its face a dark lane of material that is arrowhead-shaped. Once thought to be a dark nebula, analysis of Palomar plates shows it is merely a chance alignment. If anyone can identify this region, they are encouraged to send in observations for publucation in the next issue.

In a finder scope this object appears as a bright oval glow with a bright orange star on its southeastern edge. A slightly fainter star lies near the cluster's center. A 60mm refractor shows it as a superb cluster of stars. Six-inch telescopes reveal a rich group of over one hundred stars. My 12.5-inch scope showed more than two hundred stars in the cluster. The accompanying sketch shows the group in my 12.5-inch scope at 66x, which yields a field of view of about 1°.

This cluster has a curious feature that sets it apart from other clusters. A dark lane runs through the middle of the group, oriented east-west. The lane terminates in a blunt arrowhead shape on the eastern end and a similar, somewhat ill-defined structure on the western end. This feature was once thought to be a dark nebula, but careful examination of photographs made with the 1.2-meter Schmidt telescope at Palomar Observatory show the dark lane is really just an area devoid of stars — it simply represents a chance alignment.

This curious feature has led several Australian amateurs to nickname the group the Football Cluster, the Easter Egg Cluster, and the Arrowhead Cluster. Can any reader identify this object?

Gregg D. Thompson
Springwood Observatory
7 Strover Court
Springwood
Queensland, Australia 4127

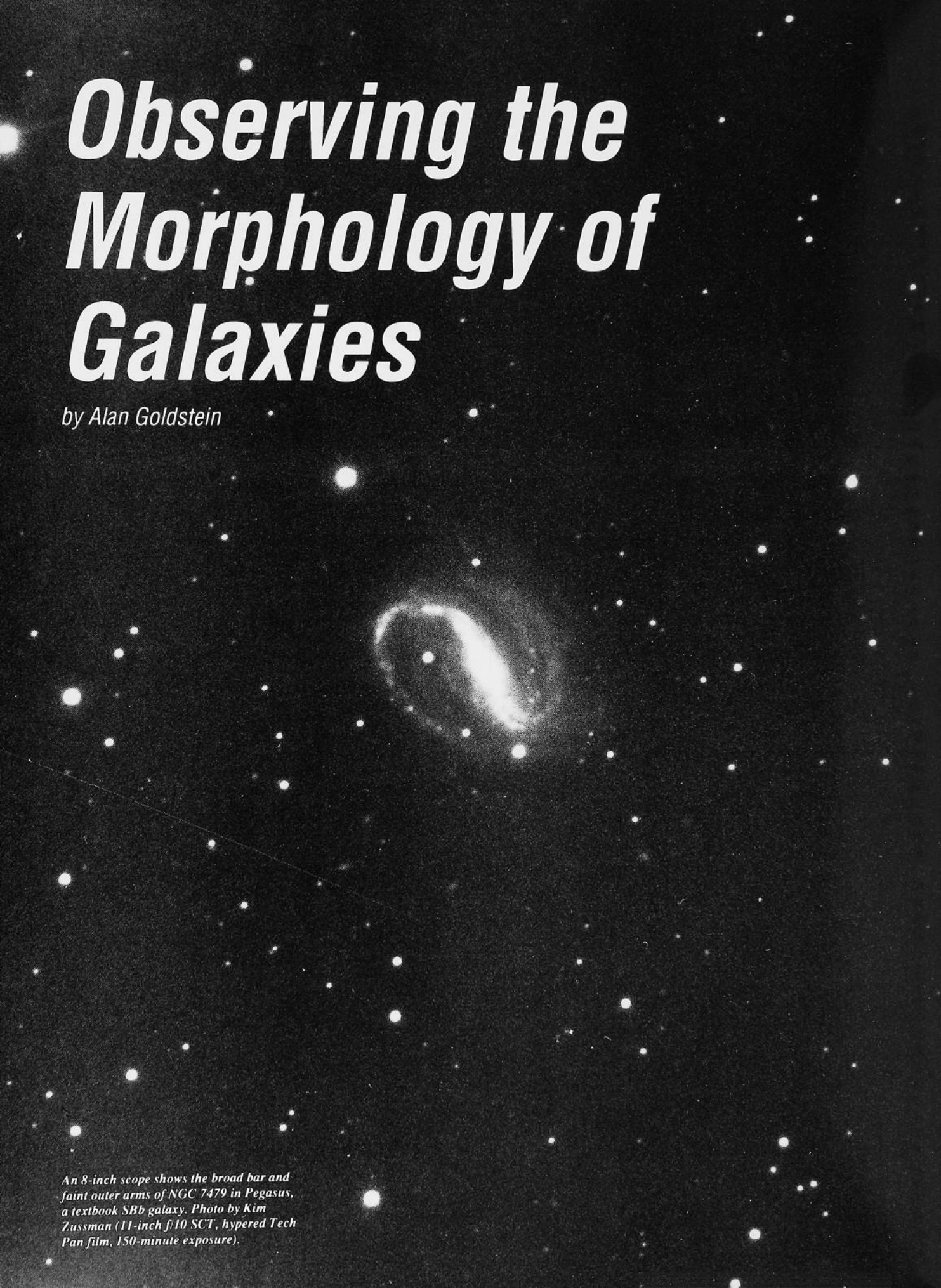
Small Scope Screwup

Dear Dave / On receipt of the Spring issue I noticed a rather crippling typo in my Small Scope Showcase column. Somehow, a "can" became a "can't," changing the meaning of what I wanted to say. I meant to say that a keen-eyed observer *can* out-resolve most amateur photographs of planetary nebulae, open clusters, and galaxies. Only CCD and image processing can reveal the range of details that the eye can see best.

Alister Ling
1017 Seneca Avenue #310
Mississauga, Ontario
Canada L5G 3X5

Observing the Morphology of Galaxies

by Alan Goldstein



An 8-inch scope shows the broad bar and faint outer arms of NGC 7479 in Pegasus, a textbook SBb galaxy. Photo by Kim Zussman (11-inch f/10 SCT, hypered Tech Pan film, 150-minute exposure).

Every reader of this magazine knows that galaxies vary over a wide spectrum of types. This fact was known before anyone knew what a galaxy really was! Observers like Sir William and John Herschel and Lord Rosse observed spiral patterns and other more subtle hints of structure with their telescopes more than one hundred years ago. You can do the same today.

The large apertures of many amateur telescopes make observing detail in galaxies relatively easy. Naturally, the closer the galaxy, the greater the details that can be resolved. This "detail" is often related to the classification to which the galaxy in question belongs. For example, spiral structure is indicative of the classification of normal or barred spirals (or occasionally the transitional barred spiral which falls between the two). Such detail is visible in galaxies that are relatively close to the Milky Way. Observing detail in galaxies, and understanding how that detail represents a particular type of galaxy, makes a wonderful observing project.

Two galaxies in the autumn sky reveal spiral structure and H II regions even with small instruments: M31 and M33. However, these galaxies have been discussed in great detail in earlier issues of this magazine. Consequently, we'll take a look at other galaxies that may be overlooked by observers who have not developed a comprehensive observing program.

As you read over this article and take your copy of the magazine outside this autumn, try to observe examples from each of the classes of galaxies we'll discuss. Observers with large aperture telescopes and keen eyes will be able to see structural detail that give clues to a galaxy's classification. Details to note include the proportion of the arms to the diameter of the central hub in spiral galaxies and the degree of oblateness in elliptical galaxies. Observers with small scopes will have a more challenging time spotting these details, but they are certainly visible under superior conditions.

Before we investigate individual galaxies, let's review the classification scheme. Edwin Hubble developed the basic system used to classify galaxies that is used today. He broke down the classification of normal spirals as Sa, Sb, Sc, and the barred spirals as SBa, SBb, and SBc.(Sa and SBa types had the largest central hubs and the least defined spiral arms.)

Elliptical galaxies were classified from E0, if circular in shape, to E7, if highly elliptical. Irregular galaxies were those with no organized structure. Peculiar galaxies were those that "fell between the cracks" in the classification scheme. Hubble soon realized that there were galaxies that fell between the spiral and elliptical classification in the "evolutionary sense" (there is no evidence to believe that galaxies evolve through the classification system). He designated these galaxies as type S0/SB0 and called them lenticular (lens-shaped) galaxies.

More recently other modifications have been made. Spirals with a distinct, though poorly developed, bar-shaped hub have been designated as transitional barred spirals — Sb type. Spirals with poorly organized arm structures have been designated Sd (an extension from Sc) and Sm (magellanic-type, with very poorly developed arms, like the Large Magellanic Cloud). In addition, the differences between the major types of galaxies have been smoothed out by introducing transitions between them (i.e. Sab, Sbc, Scd, etc.). Sidney van den Bergh introduced an "anemic" spiral galaxy which is characterized by a low surface brightness, a lot of interstellar gas, and a low concentration of stars.

The best examples of the Sa-type spiral galaxy are **NGC 7814** in Pegasus and **NGC 681** in Cetus. Both are in the 12th-magnitude range, although NGC 7814 is slightly brighter. In addition, both are highly inclined to our line of sight and appear nearly edge-on. NGC 7814 has a very thin equatorial dust lane, which may be glimpsed with a large aperture telescope. NGC 681 is a fainter version of the Sombrero galaxy, M104. Do you see its dark lane? What is the smallest aperture necessary to observe the shape? Unlike Sb and Sc galaxies, edge-on Sa-type spirals are still rather rotund in appearance because of their huge central hubs.

There are many choice Sb-type galaxies gracing the autumn sky. Yet each one is unique. Two examples are **NGC 7217** and **NGC 7331** in Pegasus. (NGC 7331 is the brightest galaxy in the constellation.) If you have tried to locate Stephan's Quintet, chances are NGC 7331 was your starting point. NGC 7217 is less well-known. At 11th magnitude it is a bright target for most telescopes. Picking up arm structure is certainly a challenge. This galaxy's arms are very fine and have a low surface brightness when compared to the central hub.

NGC 891 in Andromeda is another well-known Sb galaxy. After NGC 4565 in Coma Berenices, this galaxy is the best galaxy in which to observe an equatorial dust lane. Its surface brightness is fairly low, so dark skies are required for a good view. The view is one you are not likely to forget!

NGC 772 falls between the Sb and Sc classification. It is the brightest galaxy in Aries. This galaxy has a companion, NGC 770 (described below), and is experiencing gravitational distortions in the arms due to the interaction. A large aperture telescope may reveal an oddly placed bar shape in the arms. Can you find it?

There are a plethora of Sc spiral galaxies in the evening sky. Besides M33, **NGC 253** in Sculptor is one of the best. It does not take a lot of aperture to see detail, generally in the form of light and dark mottling. The spiral arms are very difficult to resolve, even in photographs, because this galaxy is highly inclined to our line of sight. With a large telescope, the galaxy is one of breathtaking beauty. I've detected mottling in NGC 253 with a 1-inch refractor under the most ideal sky conditions. What can you see?

NGC 6946 in Cepheus is another nice Sc galaxy. Its position in the rich star fields of the Milky Way and its nearly face-on appearance add to the difficulty in seeing it. You should pick it up without difficulty with a 6-inch telescope. In addition to a low surface brightness, this face-on galaxy lies behind galactic dust, which dims the galaxy by about two magnitudes. Its spiral arms are visible with large aperture instruments, but can you see the largest H II region? I have not yet been able to detect it.

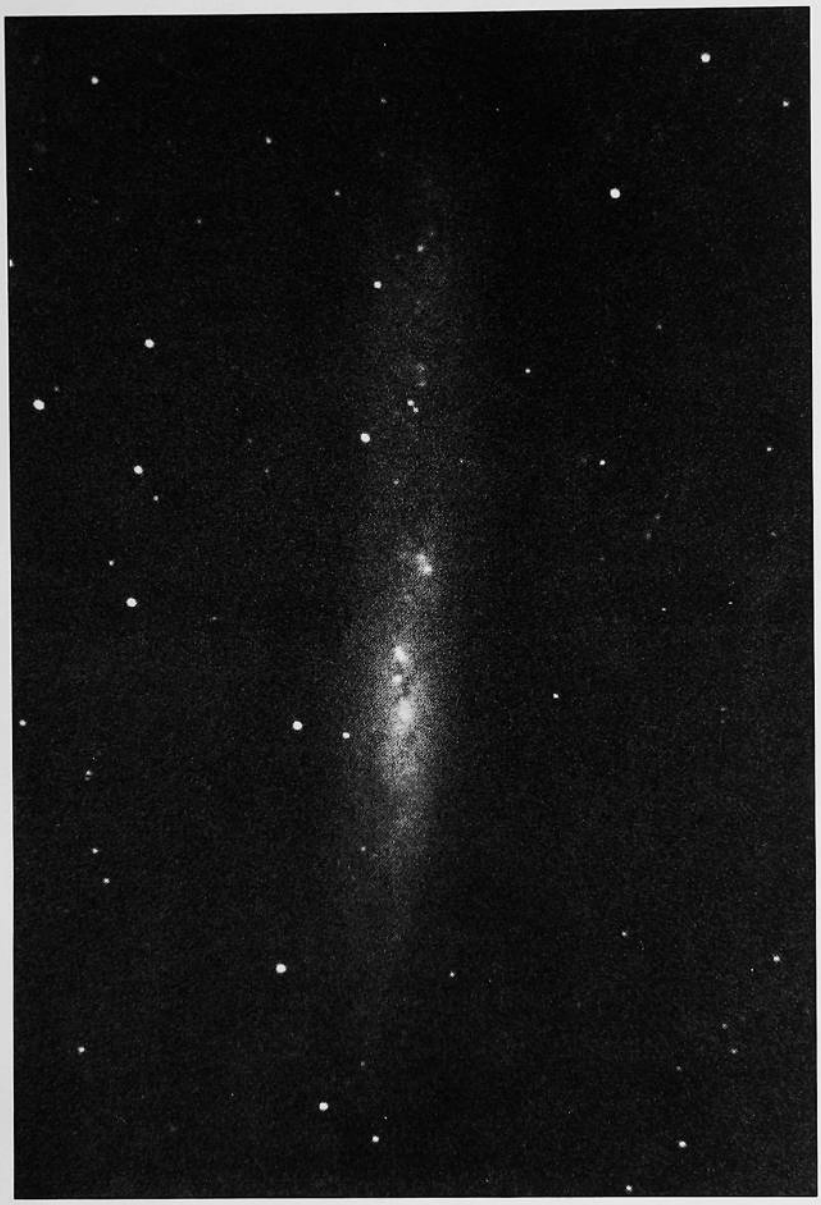
Sd spiral galaxies tend to be on the low-mass side. Perhaps it is this low mass that makes spiral structure so loose and hard to define. The two brightest galaxies of this class have southern declinations. While both galaxies have relatively high photographic magnitudes (around 9.5), they have low surface brightnesses and are deceptively dim. With today's large aperture scopes, both offer a challenge to resolve arm structure. **NGC 7793** in Sculptor has more ill-defined arms. **NGC 247** in Cetus has one relatively conspicuous arm. What can you see?

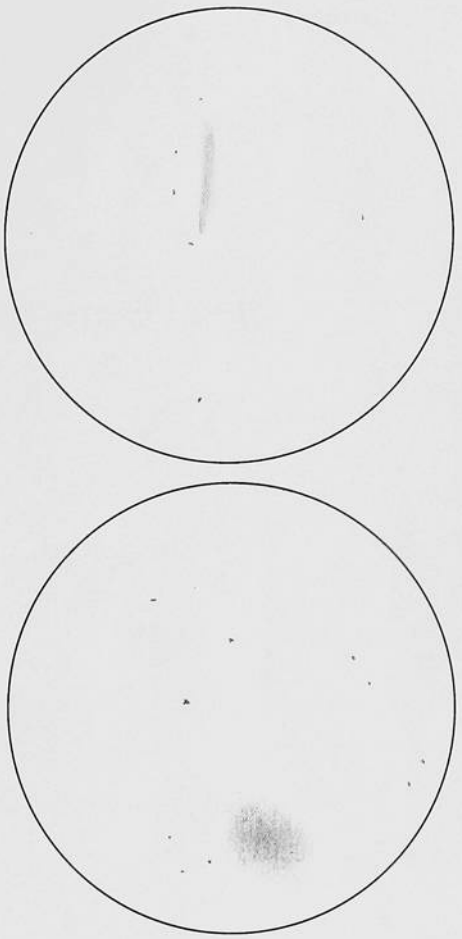
One of the most difficult targets for observers is **IC 10**, a very loose spiral galaxy in Cassiopeia. Like NGC 6946 described above, it is obscured by interstellar dust and has a low surface brightness. The spiral designation may be considered arguable. Sdm types, like Sm galaxies, have very poorly organized arms. The structure is only visible with long-exposure photographs. This writer is confident in saying you will not see any structure. The challenge for you is observing this "ghost" galaxy.

NGC 6951 is another less well-known galaxy in Cepheus. At almost 12th magnitude, it can be observed in most telescopes. This writer is not familiar with amateurs observing any structural detail in this transitional barred spiral galaxy. Detail typically appears as an oval glow with a brighter nucleus.

The only bright SBa galaxy in the autumn sky, **NGC 7410**, is located in the far southerly constellation of Grus. Those with access to a - 39° declination should be able to pick up this bright galaxy even in small scopes. Arm development in the SBa type is weak at best. Observers in southerly latitudes may be able to pick out structural detail in NGC 7410.

Loose, knotty arms characterize Sculptor's low surface brightness galaxy NGC 247, an Sd galaxy. Photo by Martin C. Germano (8-inch f/5 reflector, hypered Tech Pan film, 45-minute exposure).





Left: Sculptor's NGC 55 is an SBbc galaxy that shows a bright nucleus and a single bright patch in its arms in small telescopes. Photo by Martin C. Germano (8-inch f/10 SCT, 103a-F film, 55-minute exposure).
Top: Visually, an 8-inch f/10 SCT shows NGC 55 as a slender streak of light surrounded by a chain of faint stars. Sketch by Alan Goldstein (8-inch f/10 SCT at 50x).
Above: The Sc galaxy NGC 6946 appears as a round patch of low surface brightness light. Sketch by Alan Goldstein (12-inch f/4 reflector at 35x).

NGC 7479 is a beautiful barred spiral (SBb) in Pegasus. At 11.6 magnitude, it can be seen with small telescopes. Larger instruments are needed for resolving the arms. In most scopes this object is little more than an elongated glow. **NGC 925** in Triangulum is about a magnitude brighter than NGC 7479. In large instruments an arm-shaped pattern can be seen in the area south following the nucleus. Its bar-shaped hub is distinct from the glow of the disk.

NGC 55 in Sculptor is very bright and would have no doubt been seen by Messier if it was higher in the sky. At 7.8 magnitude this SBbc galaxy can be seen in binoculars. An 8-inch telescope can clearly resolve two bright spots. The brightest spot is in the hub, the other is a star cloud forming the junction with the arm. The orientation of the galaxy makes details scanty at best. The faint glow trailing away from the hub is another bar-shaped hub that extends away from us in space. This galaxy is being viewed from a unique perspective!

Three SBc barred spirals in autumn sky are all interesting and not at all alike. **NGC 7640** in Andromeda glows at about magnitude 10.5. Its classification was very difficult to determine because of its edge-on orientation. Unlike NGC 55, this galaxy's arm structure could be seen through photographic rectification (described in detail in *Deep Sky* #12 [Fall 1985]). Like NGC 925, one arm is apparent with large aperture telescopes in the northeastern direction.

NGC 672 in Triangulum is a loosely structured SBc galaxy. This may be due, in part, to a possible interaction with IC 1727, an even looser barred spiral nearby. The bar and subtle indications of an arm may be seen with large optics. With smaller scopes, NGC 672 has a distinctly elongated appearance. This galaxy is highly inclined to our line of sight; however the arms are open and still readily visible in photographs.

NGC 1097 in Fornax is another bright galaxy. Again, its southerly declination keeps it off the "top ten list." In photographs, two large, well-developed arms are visible, beginning at each end of the bar-shaped hub. Halton C. Arp noted that both arms appeared to be sheared by jets emanating from the nucleus. This was in one of the few spiral galaxies known with exploding jets. The arms can be visible with moderate-sized telescopes, and a stellar nucleus can also be seen. It is unlikely that the kinks in the arms, where the shearing occurs, will be seen visually.

NGC 7457 is a type S0a, a lenticular galaxy, found in Pegasus. This galaxy is small, at 12.2 magnitude, and requires a modest aperture to be seen. It is unlikely that any detail can be seen with a large aperture scope.

NGC 404 is another S0a-type galaxy. Located in the glare of Beta Andromedae, it can be seen with small instruments. It appears as a round glow slightly

Kim Zussman's photograph of NGC 6946 shows a tiny nucleus surrounded by loose, dim arms, set in a rich star-field. Zussman used an 11-inch f/10 SCT, hypered Tech Pan, and a 120-minute exposure).

Another bright Sc galaxy is M33 in Triangulum, a naked-eye object under a very dark sky. Telescopes show M33's nearly face-on arms and patchy distribuition of light. Photo by Martin C. Germano (8-inch f/5 reflector, hypered Tech Pan film, 45-minute exposure)

Galaxies by Morphological Type

Sa: NGC 681, NGC 7814
Sb: NGC 488, NGC 891, NGC 7217, NGC 7331, NGC 7723
Sbc: NGC 772, NGC 3344. NGC 7469
Sc: M33, M101, NGC 253, NGC 300, NGC 2403, NGC 6946, NGC 7314, NGC 7448
Sd: NGC 247, NGC 4395, NGC 7793
Sdm: IC 10, IC 5152
Sm: IC 3356
Sb: NGC 6951
Sc: NGC 1232
SB: M81
SBa: NGC 7410
SBb: NGC 151, NGC 4236, NGC 7479
SBbc: NGC 55
SBc: NGC 672, NGC 925, NGC 1097, NGC 7640
SBm: NGC 2366
S0p: NGC 7625, NGC 7679
S0a: NGC 404, NGC 474, NGC 7457.
S0ap: NGC 128
S0b: NGC 1201
SB0: NGC 16, NGC 1023
Aa: NGC 718
E0: NGC 750/1
E0p: NGC 7742
E3: NGC 7619
E4: IC 1459
E5: NGC 770
E6: NGC 147
I: IC 1613
IBm: NGC 1156
Ring: NGC 985, NGC 7714/15
Sp? or Ep?: NGC 1275

brightening toward the middle. NGC 404 bears magnification well, which allows it to be viewed away from Beta.

Located in Pisces, **NGC 474** is an S0a that interacts with **NGC 470**, an Sc galaxy. The pair is 227 in Halton C. Arp's *Atlas of Peculiar Galaxies*. NGC 474 appears as a tiny circular glow, considerably smaller than the fainter NGC 470. The peculiar halo surrounding NGC 474 is much too faint to be seen visually.

NGC 128 in Pisces is another peculiar S0a-type lenticular galaxy. The curious feature with this galaxy is the box-shaped central hub. Its edge-on appearance should be readily visible with larger aperture. The odd shape of the hub may be visible with the largest optics. Companions **NGC 127** and **NGC 130** may be seen nearby, as well as some other galaxies.

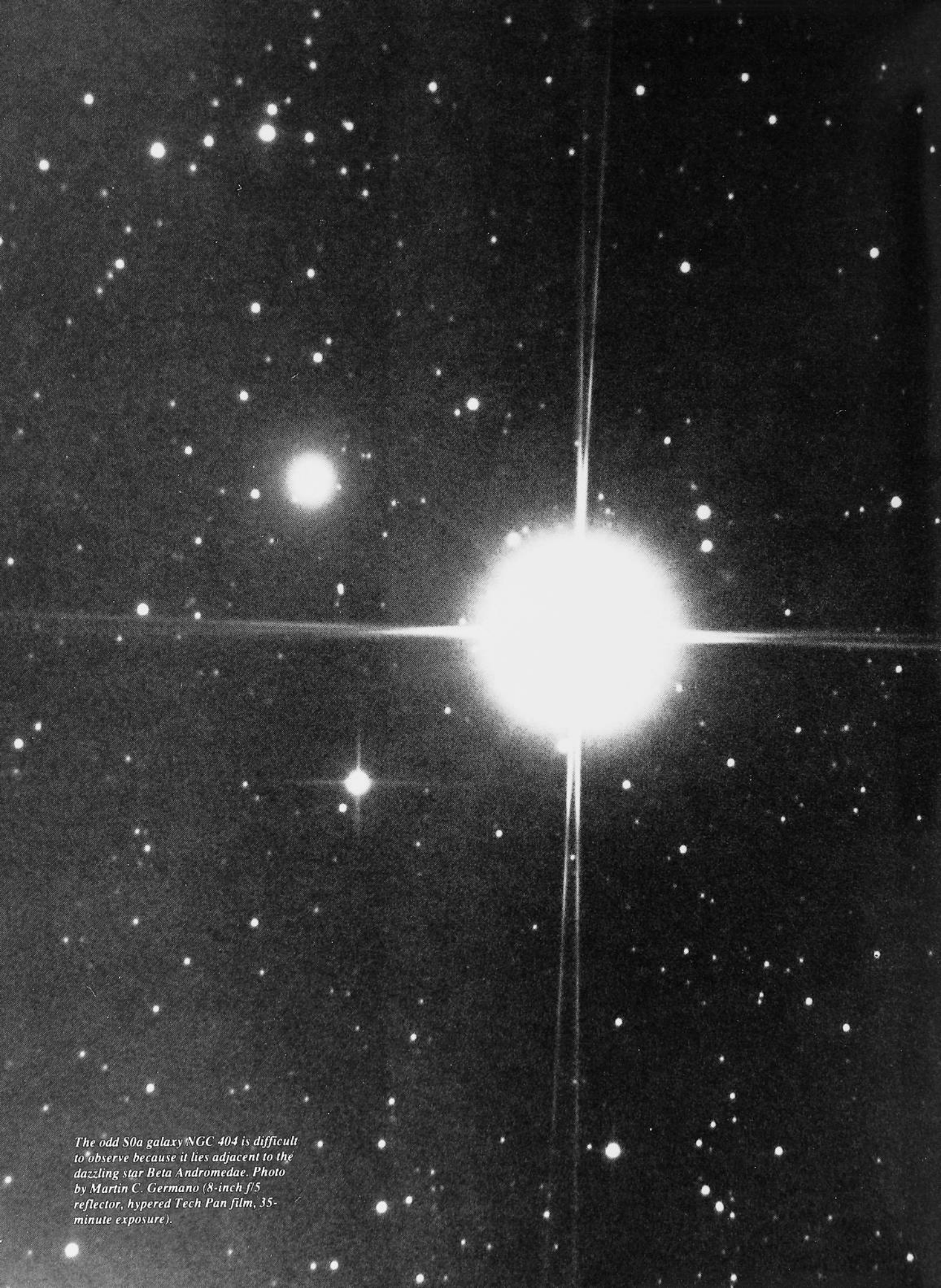
Located in Fornax, **NGC 1201** is not the brightest galaxy in the constellation, but it has the distinction of being the best example of the classification S0b in autumn. This S0b appears as an elongated glow. The brighter nuclear region is distinct in a larger telescope. The southerly declination makes it a greater challenge for northern observers, but it is bright enough to be seen clearly with a 6-inch aperture.

NGC 16 is faint but is an example of one of the uncommon SB0 class (barred lenticular galaxy). **NGC 1023** in Perseus is another SB0-type and is considerably brighter. Both appear as elongate glows, NGC 1023 more so. Neither galaxy shows any detail with larger optics.

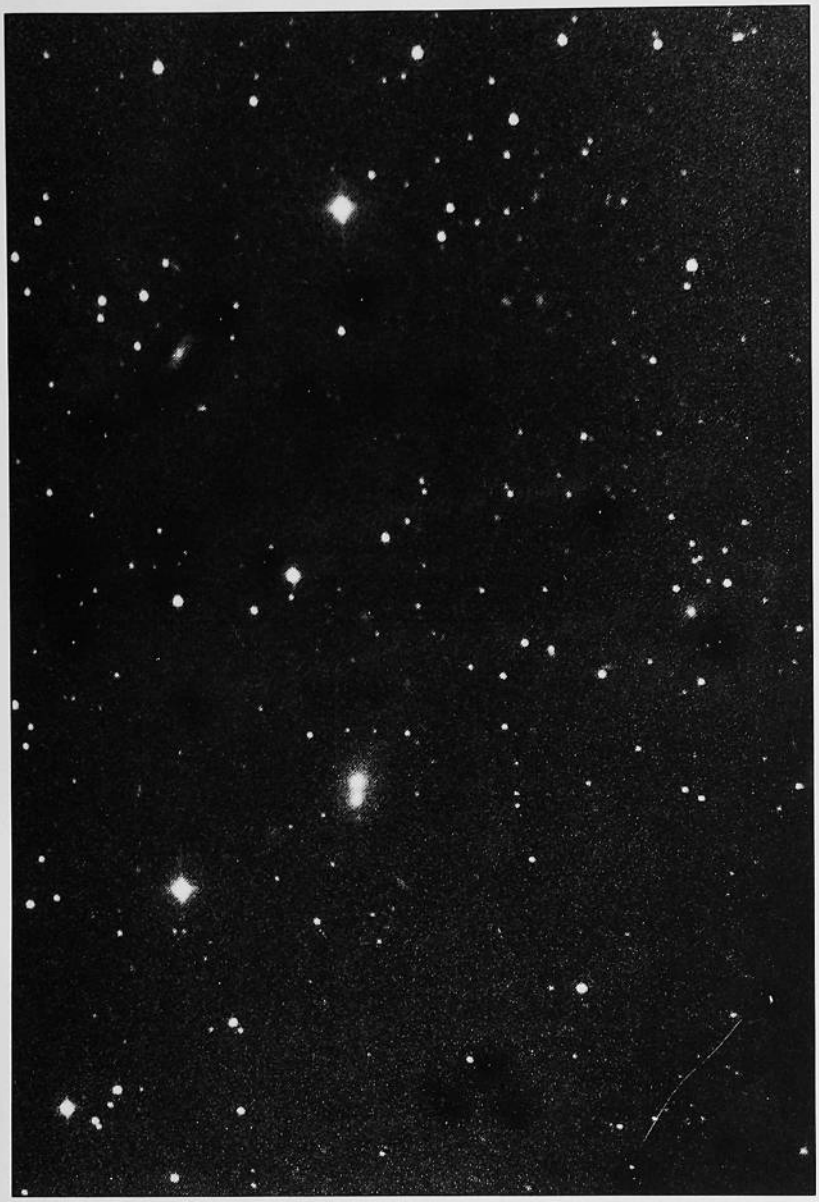
NGC 7625 is a peculiar lenticular galaxy in Pegasus. Also designated Arp 212, this galaxy is very faint, appears as a roundish wisp, and is considered a challenge to observe in smaller telescopes. **NGC 7679** is another faint peculiar galaxy. I have seen this galaxy, also known as Arp 216, described as a peculiar lenticular galaxy or a giant intergalactic H II region. Whatever the case, this weird object is located in Pisces and is worth tracking down. NGC 7682 lies in close proximity.

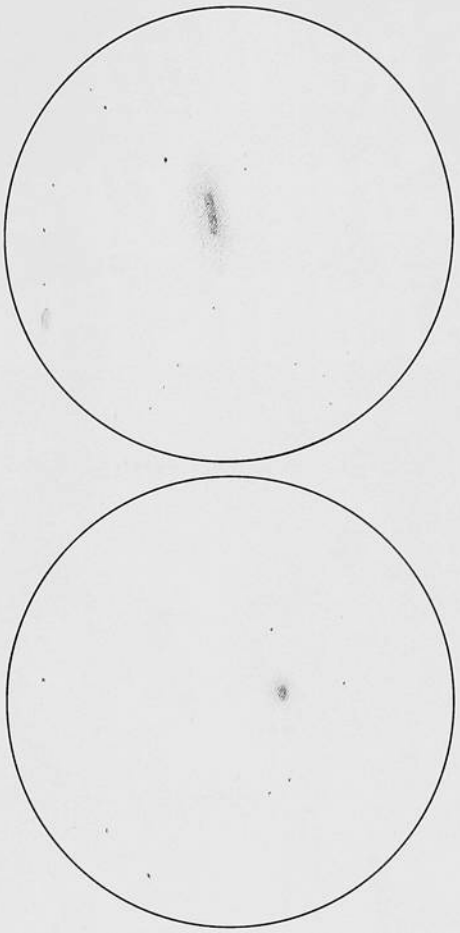
NGC 718 has been classified in the past as a Sa or Sb spiral. It appears to meet the criteria for an anemic spiral galaxy designated type Aa. Located in Pisces, this photographic magnitude-12.5 galaxy is the brightest anemic galaxy in the autumn sky. It appears as a soft, roundish glow.

There are several noteworthy galaxies of type E0. **NGC 7742** in Pegasus is listed as having peculiar characteristics. At photographic magnitude 12.2, this round object can be seen in modest instruments. Typical of elliptical galaxies, there are no "details" to be seen. **NGC 750** and **NGC 751**are a faint pair of E0 galaxies in Triangulum. Both galaxies glow at 13th magnitude and are in contact. An observer who is not careful may note this pair as one elongated system! This error is made in the *Skalnate Pleso Atlas Catalogue*. This catalogue lists the dimensions as 0.6' by 0.3'.



The odd S0a galaxy NGC 404 is difficult to observe because it lies adjacent to the dazzling star Beta Andromedae. Photo by Martin C. Germano (8-inch f/5 reflector, hypered Tech Pan film, 35-minute exposure).





Left: Triangulum's galaxies NGC 750 and NGC 751 form a unique pair of E0 galaxies. Photo by K. Alexander Brownlee (16-inch f/5 reflector, 103a-O film, 60-minute exposure).
Top: NGC 672 is an SBc galaxy that appears as a bright, elongated disk surrounded by a faint glow. Sketch by Alan Goldstein (11-inch f/10 SCT at 175x). The satellite galaxy IC 1727 lies at the edge of the field.
Above: A typical Sb galaxy, NGC 7723 is a roundish smear of light in small telescopes. Sketch by Alan Goldstein (8-inch f/10 SCT at 50x).

However, each galaxy measures 0.3' by 0.3'. A large telescope is useful for a clear look at this pair, which is also known as Arp 166.

Located in Pisces, **NGC 7619** is little more than a moderately bright E3 galaxy. This elliptical galaxy shows a brightening toward the center and tends to be slightly elongated. The best example of an E4 galaxy in the autumn sky is IC 1459 in the southern constellation Grus. If sky conditions permit, it appears as an oval patch. Observers with better southern horizons will see the brighter central glow easier. **NGC 770** is a small E5 galaxy next to NGC 772 in Aries. It is faint, about 13th magnitude, and required a moderate aperture and good skies to be seen well.

NGC 147 in Cassiopeia is a dwarf E6 galaxy. It is somewhat ghostly in appearance. NGC 147 is a member of the Local Group and is about the same distance as M31. The central condensation is not apparent as with other elliptical galaxies. **IC 1613** is a very faint irregular galaxy in Cetus. It is a challenge to resolve and requires a large aperture and short focal length. At 11' across, it is about the same diameter as the long axis of NGC 205.

NGC 1156 is a fairly bright IBm. It is a magellanic-type barred irregular galaxy in the constellation Aries. At photographic magnitude 11.6, it can be seen in a 6-inch telescope. This galaxy doesn't reveal much detail with larger scopes but is definitely worth the effort to observe.

There are several other galaxies worth observing, because they do not fall into the regular classification scheme. These peculiar galaxies are noteworthy for different reasons. **NGC 7714/5** is a ring galaxy, an effect caused by intergalactic collisions. All ring galaxies have a low surface brightness, so don't plan on seeing a ring shape!

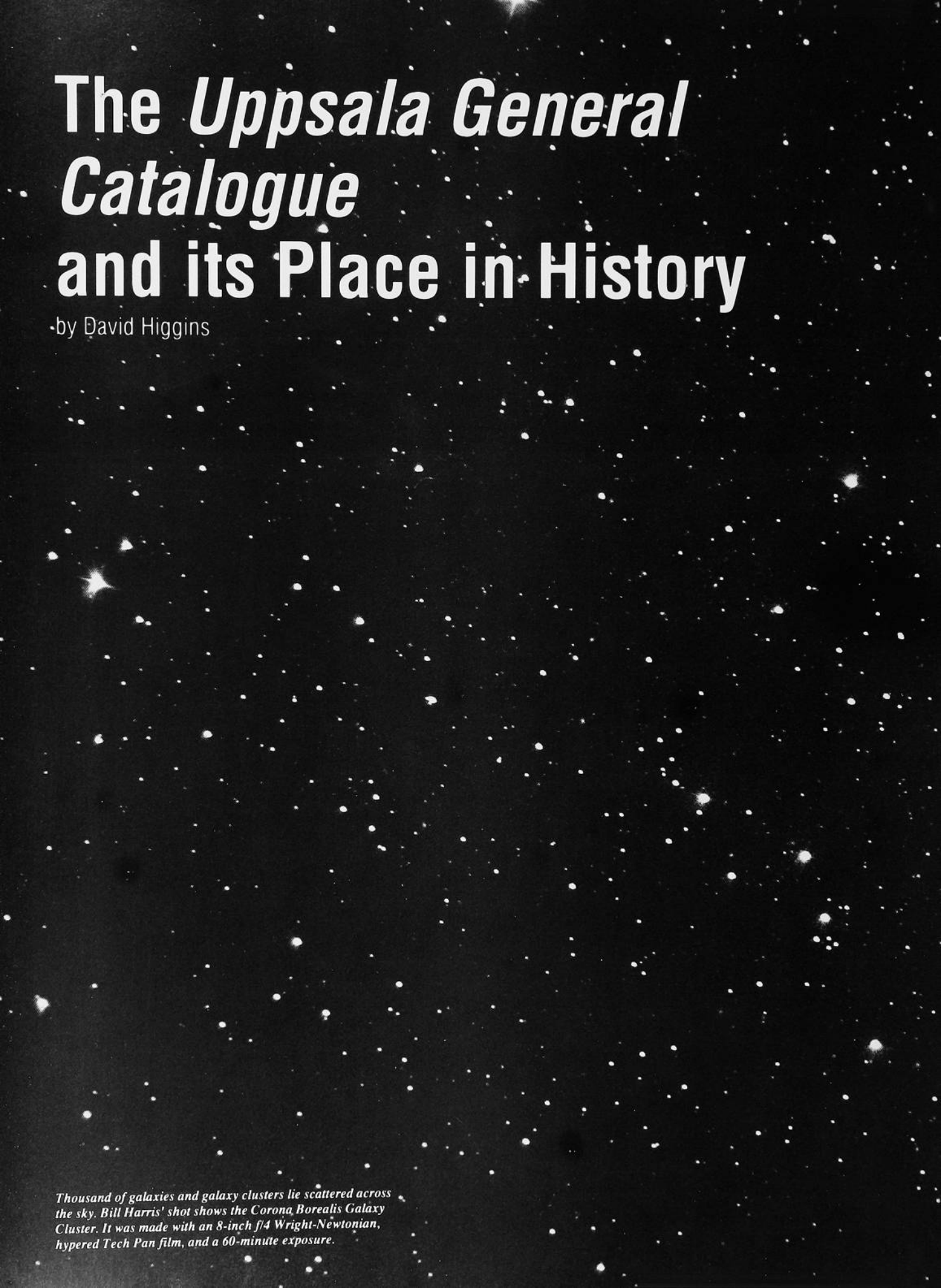
NGC 985 in Cetus is an example of the unlikely case of both a ring galaxy and a Seyfert galaxy with an exploding nucleus. Like NGC 7714/5, don't plan to see much detail, although this one has a bright stellar nucleus (brighter than the typical magnitude 13.5 galaxy).

NGC 1275 is a peculiar Seyfert galaxy and a bright radio emission source. It is a small member of the Perseus galaxy cluster, but it is not difficult to observe with a 6-inch aperture. The filamentary structure is much too faint for visual observation.

Get outside this autumn and see how many different classes of galaxies you can see. The galaxies I have mentioned represent just the tip of the iceberg. Remember that to see the maximum amount of detail possible with your instrument the skies must be optimum. Naturally, *Deep Sky* magazine and the National Deep Sky Observers Society are always interested in receiving copies of your sketches, observing notes, photographs, or other records that pertain to observing sttructure in galaxies.

The *Uppsala General Catalogue* and its Place in History

by David Higgins



Thousand of galaxies and galaxy clusters lie scattered across the sky. Bill Harris' shot shows the Corona Borealis Galaxy Cluster. It was made with an 8-inch f/4 Wright-Newtonian, hypered Tech Pan film, and a 60-minute exposure.

With the arrival of autumn, the night sky seems to snap neatly into focus. Gone are the sweltering days, humid nights, and flying critters of summer. In their place, crisp nights provide good seeing, putting a spring in the steps of astronomers and in general making everyone a little more agreeable. Observing during this time of year is both comfortable and enjoyable.

During early autumn a few of the summer constellations still provide us with a great variety of dazzling objects to observe. As the nights progressively grow longer, however, the great autumn "void" swings into place and the evening sky is dominated by galaxies. Large or small, bright or dim, galaxies are fascinating. They offer fascinating shapes, sizes, and brightnesses, and patient observers can spy varying structural details.

Backyard astronomers are familiar with basic deep-sky catalogues. The *Index Catalogue*, the *Revised New General Catalogue*, and the *Messier Catalogue* are among the most widely used. However, one catalogue that is not well known — at least in the amateur community — offers a wealth of information and an almost unlimited supply of galaxies for study with large telescopes.

The *Uppsala General Catalogue of Galaxies* provides positions and a vast amount of information on thousands of galaxies. Getting to know this fascinating catalogue and its place in history is an eye-opening exercise that will change the way you observe. But first, let's review some forerunner galaxy catalogues and explore the ways they've evolved.

UGC 1276 is a 14th-magnitude patch of light in Aries that measures 2.0′ by 0.9′. It is a difficult object for small telescopes. Each of the sketches in this article was made by the author with a 24-inch f/4 reflector.

Cataloguing the Universe

Like other scientists, astronomers have a passion for cataloguing things. As far back as A.D. 127, Claudius Ptolemaeus (c. 83-161), better known as Ptolemy, produced a catalogue of stars known as the *Almagest*. Within this catalogue Ptolemy included seven nebulous objects, but in reality none of the objects were nebulae. Instead, they were large star clusters.

The Persian astronomer Al-Sufi (903-986) produced a catalogue known as *The Book of the Fixed Stars* sometime before A.D. 986. Of course, some of his observations were based on Ptolemy's work, but with one major difference. Al-Sufi's work included not only Ptolemy's seven nebulous objects, but also a nebulous object in Andromeda, which Al-Sufi described as a "little cloud." In his book *The Search for the Nebulae*, Kenneth Glyn Jones mentions that European observers were not aware of the cloud in Andromeda until 1612 — more than six centuries later!

Late in the sixteenth century, the Danish astronomer Tycho Brahe (1546-1601) produced a catalogue that contained positions of 777 stars. Published after Tycho's death by his student Johannes Kepler, Tycho's catalogue was significantly expanded and republished in 1627. This 1627 edition contained six nebulous objects. Curiously, Tycho's revised catalogue did not include the fuzzy patch in the Andromeda.

The next important astronomer to catalogue nebulae was Britain's first Astronomer Royal and director of the Royal Observatory, John Flamsteed (1646-1719). Flamsteed's greatest contribution was his star catalogue, *Historia Coelestis Britannica*, a work compiled over a span of thirty years. In this monumental work Flamsteed included sixteen objects as "nebulous" but in fact only two objects were not star clusters. They were M42 and the Andromeda Galaxy.

A contemporary of Flamsteed's, Edmond Halley (1656-1742), is one of history's most notable astronomers because of his prediction of the return of his famous comet. Halley also became the first to publish a list of nebulae distinctly separate from a star catalogue. His contention that these nebulae shone by their own light and occupied "an extraordinary great space" did not agree with the feelings of most astronomers of the day.

Halley's list paved the way for others to come. The French scientist Jean-Jacques de Mairan (1678-1771) and the British clergyman William Derham (1657-1735) jumped into the fray. But the man responsible for the next jump in original thinking on nebulae was Philippe Loys de Cheseaux (1718-1751). His catalogue contained twenty objects — which is not remarkable in itself — but his list contained eight nebulae and clusters that had not been included in previous catalogues. The catalogue produced by Cheseaux

UGC 11909 is one of the brightest UGC galaxies in the autumn sky, glowing at magnitude 13.3. Its dimensions of 3.2' by 0.7' make it visible as a slender streak of light with a 6-inch telescope on dark nights.

also represented the first attempt to classify the objects. He divided the objects into two groups: star clusters, groups of stars that could be resolved; and nebulae, objects that did not look like anything but white clouds.

The Great Era of Discovery

The mid-eighteenth century brought new names and attitudes toward cataloguing the sky. The Abbe Nicolas Louis de Lacaille (1713-1762) was a professor of mathematics and astronomy at the College Mazarin in France. His trip to the Cape of Good Hope in 1750-1754 not only allowed him to accurately catalogue the positions of 9,776 Southern Hemisphere stars, but also gave him the opportunity to catalogue forty-two additional nebulae and star clusters of which most were new discoveries.

Lacaille not only catalogued new nebulae but took Cheseaux's system of classification a step further. Whereas Cheseaux's catalogue contained two classes of nebulae, Lacaille created three separate categories of objects. Nebulae without stars comprised the first class, class two consisted of nebulous stars in clusters, and the third class consisted of stars with nebulosity.

Lacaille's star catalogue, *Coelum Australe Stelliferum*, was not published during his lifetime but was completed in 1763. His catalogue of nebulae was published as a *Memoire of the Academie Royale des Sciences* in 1755.

But then came Charles Messier (1730-1817), a French comet hunter who produced the most widely known catalogue of deep-sky objects in history. The catalogue's fame is well deserved because all of the objects in Messier's catalogue are visible in small telescopes.

The Messier catalogue was originally produced to alleviate confusion between comets and nebulae. Messier published two catalogues, the first in the *Memoires of the Academie Royal des Sciences* in 1771. In this first publication the catalogue contained not only descriptions of forty-five nebulae and clusters that Messier had found, but also objects found by other earlier observers. During the years to come, Messier discovered additional objects that he published in the form of an augmented list of sixty-eight objects in the *Connaissance des Temps* for 1783, which was published in 1780. Two additional objects were discovered and included in an addendum to the *Connaissance des Temps*, bringing the total to seventy. Messier produced his last list of nebulae in the *Connaissance des Temps* for 1784. Altogether, 103 objects were included in the final list. However, several other objects were subsequently added by other observers.

During this period another observer was busy publishing a catalogue of nebulous objects. John Elert Bode (1747-1826), the first editor of the French journal *Astronomisches Jahrbuch*, published his *Complete Catalogue of Nebulous Stars and Star Clusters* in the *Astronomisches Jahrbuch* for 1779, which was published in 1777.

Bode's list contained seventy-five objects and might have made a bigger impact than Messier's list. But it didn't. Bode's catalogue contained far too many errors and misprints. One of the worst problems was that the list was inflated by numerous asterisms and non-objects. Although the Messier catalogue contained a few asterisms, it was nevertheless much more reliable and and useful than Bode's catalogue.

The Greatest of the Great

Even in today's high-tech world, no one has surpassed the accomplishments of William Herschel (1738-1822). This German-born musician-turned-astronomer discovered 5,079 nebulae and clusters. He also discovered Uranus and published several catalogues of double stars. Together with his sister Caroline Herschel (1750-1848) and his son John Frederick William Herschel (1792-1871), Herschel used an 18.5-inch telescope to survey the entire sky. In 1783 he presented his first *Catalogue of One Thousand New Nebulae and Clusters of Stars* to the Royal Astronomical Society.

William Herschel's love of the sky led him to observe on every clear night. Because of this, he racked up an incredible number of discoveries. For example, in 1789 he published one thousand discoveries in the *Transactions of the Royal Astronomical Society*. By 1802 Herschel had added another five hundred objects to the growing list of nebulae and clusters.

UGC	R.A.(2000.0)	Dec.	Con.	Mag.	Size
1276	1h46.5m	+20°27'	Ari	13.8	2.0'x0.9'
1385	1h52.1m	+36°41'	And	14.2	0.8'x0.6'
1551	2h00.8m	+23°50'	Ari	14.1	3.0'x1.5'
12682	2h11.1m	+03°53'	Peg	14.7	1.6'x1.3'
2105	2h34.6m	+34°14'	Tri	13.9	1.6'x1.3'
11909	22h04.3m	+47°00'	Lac	13.3	3.2'x0.7'
12064	22h29.1m	+39°06'	Lac	14.6	1.1'x1.1'
12588	23h22.3m	+41°04'	And	14.0	1.8'x1.8'
12710	23h25.0m	+17°44'	Peg	14.7	1.5'x0.9'
12856	23h54.0m	+16°33'	Peg	14.5	2.6'x0.9'

William Herschel was not only an expert observer but also an accomplished telescope builder. He ground hundreds of mirrors and at one time had the largest telescope in the world, a 48-inch instrument. Although this telescope was a marvel to all who saw it, Herschel preferred his 18.5-inch scope for sweeping the heavens.

This telescope continued to serve after Herschel's death, when his son John took it to the Cape and discovered 1,700 nebulae and clusters between 1834 and 1839. In 1863 John published his *Catalogue of Nebulae and Clusters*, a work that not only included his own observations but those of his father and other observers as well. A year later, this catalogue of 5,096 objects was published in the *Transactions of the Royal Astronomical Society*.

The work that has had the greatest impact on amateur astronomers and is still the standard list of nonstellar objects one hundred years after it was published is J. L. E. Dreyer's *New General Catalogue of Nebulae and Clusters of Stars*. First published in the *Royal Astronomical Society's Memoir 49*, it contains 7,480 objects. The objects are listed by right ascension and each has a description. The descriptions are still useful to amateurs today because they are based on actual visual observations and show how the objects appear through a telescope, not from photographs.

By 1895 a whole new group of nebulae had been found by various astonomers, so Dreyer published an *Index Catalogue of Nebulae*, a list containing 1,529 objects. Although Dreyer thought the objects in the *Index Catalogue* did not compare in interest with those in other catalogues, they are certainly a fascinating bunch by today's standards. By 1908, another 1,400 objects were found photographically. Dreyer's publication of the *Second Index Catalogue of Nebulae* brought the total number of objects contained in the *Index Catalogues* to 5,386. Today the combined *Index Catalogues* are considered to be an extension of the NGC.

The Uppsala General Catalogue

Although several catalogues have been produced since the NGC, let's investigate one in particular — the *Uppsala General Calaogue of Galaxies* (UGC). The UGC contains data for 12,921 galaxies. Data on the galaxies is organized in twelve columns. The first column is the UGC number. The second column lists the coordinates of the galaxy. Column 3a gives the object's number in the *Morphological Catalogue of Galaxies*, whereas column 3b lists any IC, NGC, Messier, or Markarian numbers the galaxy might have.

Column 4a gives the number of the *Palomar Sky Survey* (*POSS*) field in which the galaxy is best visible, and column 4b lists the number of the cluster in the *Catalogue of Galaxies and Clusters of Galaxies*. Columns 5a and 5b give the diameters of the galaxies as measured on the blue and red prints from the POSS.

Column 6a gives the galaxy's position angle from northeastward, while 6b gives the estimated inclination on a scale of 1 to 7. (One is face-on and seven is edge-on.) Column 7 gives a scale of 0 to 5 with 0 the most uncertain in the classification system. Column 8a gives the Hubble classification and 8b gives the galaxy's luminosity class according to Sidney van den Bergh's system. Columns 9a and 9b give the classifications according to de Vaucouleurs' and Holmberg's revised Hubble systems.

Column 10 shows the apparent photographic magnitude from Zwicky's CGCG. Columns 11a and 11b give the galaxy's radial velocity corrected for solar motion. Column 12 contains references for the excellent notes section that appears in the back of the book.

With few exceptions, galaxies in the UGC are faint and have low surface brightnesses. Although dimensions for galaxies given in the UGC may suggest the objects are relatively easy targets, many of them appear tiny in the eyepiece. Last year I chose a number of UGC galaxies from five autumn constellations to sample them and share my observations.

Tracking down the UGC Objects

I used a 24-inch f/4 telescope, but I'm sure that observers with much smaller telescopes will be

Located in Andromeda, UGC 1385 softly glows at magnitude 14.2 and spans a mere 0.8' by 0.6'. A challenging object for moderate and large telescopes, even at high power this galaxy is nothing more than a round fuzz.

UGC 12856 in Pegasus is another challenging UGC galaxy: measuring 2.6' by 0.9' and with a magnitude of only 14.5, high power and large aperture are required to spot UGC 12856.

Triangulum's finest UGC galaxy is UGC 2105, a 14th-magnitude circular object just exceeding 1' in diameter. Look for a round spot of faint light placed nearly between two faint stars.

UGC 21588 in Andromeda is perfectly round, just under 2' in diameter, and glows at 14th-magnitude. A faint star lies immediately southwest of the galaxy.

Located in Aries, UGC 1551 is a 14th-magnitude object measuring 3.0' by 1.5' and lying between two faint stars. High powers bring out this galaxy's soft light.

UGC 12064 is a faint (magnitude 14.6) round galaxy in Lacerta. Averted vision helps to maximize the galaxy's apparent brightness.

able to find most of these galaxies. The galaxies I have described will give you an idea of how difficult some of these galaxies are to observe. I've also included sketches of some of them so you will have a "finder chart" to help identify individual galaxies.

One problem with observing faint galaxies is that in many cases few bright stars lie nearby to point the way to the galaxies. Two UGC galaxies in Pegasus are exceptions to the rule. Shining at 5th magnitude, the star 75 Pegasi serves as a signpost for two faint galaxies.

About half a degree west of 75 Pegasi you'll see a line of three stars oriented north-south. The faint patch of light designated **UGC 12682** lies 0.5° further west. This irregular galaxy measures 1.6' by 1.3' in extent and glows dimly at magnitude 14.7. I did not see any sign of a nucleus in UGC 12682, and averted vision gave the best view.

Aim your scope about a degree south of 75 Pegasi and you'll see a small triangle of stars. Lying about halfway between 75 Pegasi and this triangle is the faint galaxy **UGC 12710**. This object is an irregular galaxy that glows dimly at magnitude 14.7. Measuring 1.5' by 0.9' in extent, UGC 12710 appears as a faint oval haze with no nucleus. I did detect an obvious elongation in this object, and averted vision was required for a steady view.

About a degree southwest of 81 Pegasi you'll see a string of eight or nine stars aligned northeast-southwest. Two degrees southeast of this string is the faint smudge designated NGC 7792. A little over half a degree northwest of this galaxy lies **UGC 12856**. This irregular galaxy is a little brighter and larger than the previous objects. It measures 2.6' by 0.9' and glows at magnitude 14.5. UGC 12856 appeared as a faint oval haze with no nuclear brightening.

Located in Andromeda about a degree southwest of the great star cluster NGC 752, **UGC 1385** is an extremely challenging object. This type SBa spiral spans only 0.8' by 0.6' and has a slight central brightening at high powers. The surrounding haze gradually fades toward the galaxy's edges, and a faint field star lies just to the west.

Although several galaxies are scattered around the area, finding UGC 1385 is not difficult. Move south from NGC 752 to the double star 56 Andromedae and then southwest to a 5th-magnitude star. UGC 1385 lies less than half a degree southwest of this star.

Another UGC galaxy in Andromeda lies just northeast of the bright spiral galaxy NGC 7640. At magnitude 14.0, **UGC 12588** is one of the brightest UGC galaxies. To locate it, find NGC 7640 and move 0.5° northwest. There you'll see two 7th-magnitude stars about a half degree apart. UGC 12588 lies almost midway between these two stars. Measuring 1.8' in diameter, this faint Sb galaxy displayed a subtle central brightening.

Now move southeast into Triangulum. About 5° east and a half degree north of Gamma Trianguli you'll see a faint naked-eye star designated 15 Trianguli. Roughly half a degree southeast of this star lies the magnitude-13.9 fuzz **UGC 2105**. This small, faint barred spiral has a relatively bright middle and fades gradually outward. In the eyepiece UGC 2105 is an oval 1.6' by 1.3' in extent. And although somewhat brighter than most UGC galaxies, it required averted vision to see comfortably.

South of Triangulum, Aries the Ram contains several UGC galaxies that provide some relief for squinting eyes. About 1.5° west of Beta Arietis, **UGC 1276** glows at magnitude 13.8, which is fairly bright as UGC galaxies go. UGC 1276 is an SB galaxy that is extended east-west and shows no nuclear brightening. It measures 2.0' by 0.9'. A faint field star lies to the south.

One degree northwest of Alpha Arietis, you'll find a somewhat fainter galaxy in **UGC 1551**. This SB spiral is large, faint, and irregular in shape with no hint of a nucleus. UGC 1551 measures 3.0' by 1.5'. A few arcminutes northeast lies **UGC 1561**, a magnitude 14.7 galaxy that is notoriously difficult to find. I failed to find this object with the 24-inch scope, but I suspect sky conditions have a great deal to do with finding this low surface brightness object. On a better night the galaxy may be visible with a 24-incher or even much smaller apertures.

Visually, the largest of the UGC galaxies I surveyed is **UGC 11909** in Lacerta. This object measures 3.2' by 0.7' and is elongated north-south. UGC 11909 glows faintly at magnitude 13.3 and has a low surface brightness that makes it very difficult to see. This faint spiral did not show any sign of a nucleus, but its light gradually faded out to the edges. A faint double star lies to the south.

Located 0.5° north of the open cluster NGC 7209, UGC 11909 is fairly simple to find. A 6th-magnitude star lies on the northern edge of the cluster, and just north of this star you'll see another 6th-magnitude star. A point immediately east of this star marks the galaxy's position. Much fainter and smaller is Lacerta's **UGC 12064**. Start by locating a string of 5th- and 6th-magnitude stars southeast of 6 Lacertae. About a degree west of 8 Lacertae, UGC 12064 glows at magnitude 14.6 and measures 1.1' across. This faint, irregularly shaped haze did not show any nucleus and averted vision was required for a good view. A faint field star lies to the north.

If you enjoy a challenge that requires some determination and patience, then surveying a few UGC galaxies is for you. These faint galaxies will tax your observing skills and push your telescope to its limits. Don't let the magnitudes of these galaxies or the size of your telescope dissuade you from hunting these objects. Although I used a a large telescope, much smaller scopes under good conditions will reveal some of the objects I've discussed.

David Higgins is central coordinator of the National Deep Sky Observers Society and a frequent contributor to Deep Sky. *Each year he is an active participant and/or organizer of the Texas Star Party.*

Observing Variable Stars from Down Under

by Peter F. Williams

In the last several years, there has been a growing global awareness of what the southern skies have to offer. Partly responsible for this is the establishment of major optical telescopes in Australia and South America; but most importantly, Comet Halley and supernova 1987A attracted large numbers of amateur astronomers to the wonders of the south.

During the last twenty years, I've tried my hand at all forms of observing. These days, however, I concentrate on routine variable star work in conjunction with the Variable Star Section of the Royal Astronomical Society of New Zealand. Under the directorship of Frank M. Bateson, the society has undertaken an ambitious set of observing programs for many unusual variable stars. To keep things balanced, however, I also enjoy deep-sky observing.

I have always lived on the southern outskirts of Sydney, New South Wales, and sky glow to the north hampers the area where the galactic center passes overhead during our winter evenings. Summer nights, of course, mean hopping around the Magellanic Clouds. Despite living near Sydney, I've discovered ways to enter into all types of observational astronomy.

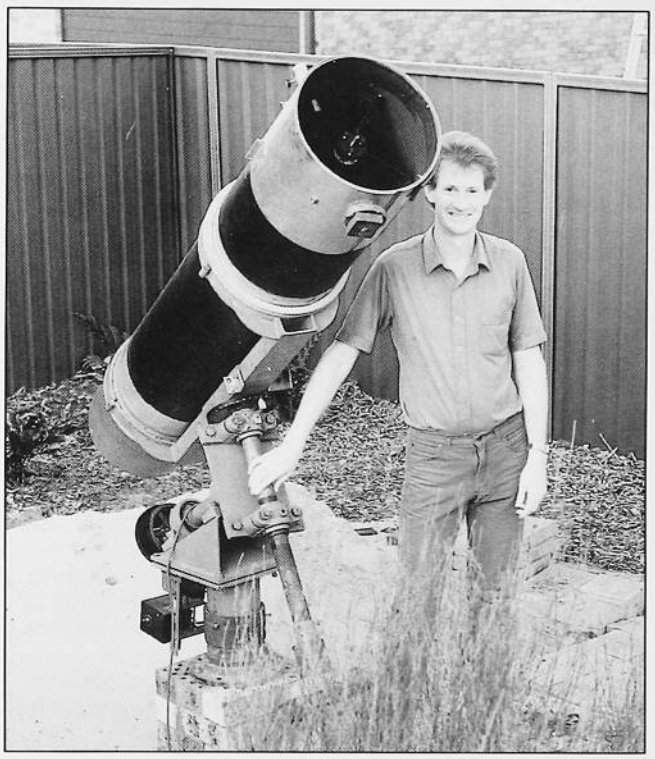
Many years ago I learned that simplicity is the key to regular observing. The less time and effort involved in setting up for an observing session, the more observing sessions there will be. Large telescopes should be permanently mounted, and a telescope of any size must be a joy to use. With few notable exceptions, large telescopes that require more than one person to transport, assemble, and operate soon fall into disuse. This unfortunate situation led to the formulation of the well-known inverse square law, wherein it has been shown the amount of observing time achieved is often inversely proportional to the square of telescope aperture.

My current telescope, a 6-inch f/8 Newtonian on an equatorial mount, has served me well since 1975. It is a true no-frills telescope without such luxuries as a drive, slow motions, or setting circles. While it does not have the light-gathering power to match today's large Dobsonians, it is an easy telescope to operate.

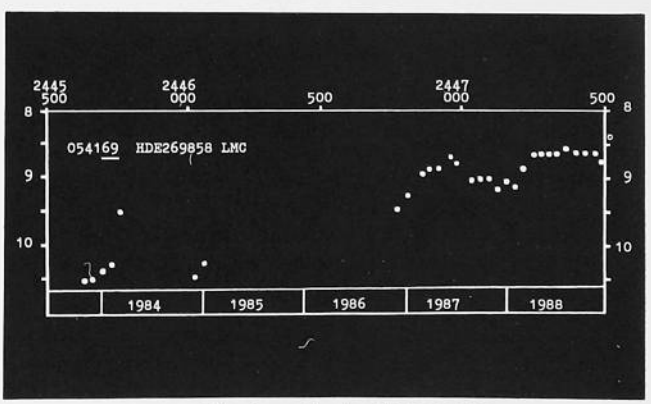
The 6-inch scope is kept fully assembled, stored in the garage and is carried out to my backyard observing site as a complete unit. Polar alignment is always rough, but close enough is sufficient for the type of variable star work I do. Unlike astrophotographers, I never remain on one field for longer than a minute or two. The grass underfoot tends to absorb virtually all telescope vibrations.

A folding chair, table, red-light torch, several folders of charts, recording sheets, and an atlas complete the observing setup so I can commence observing in as little as five minutes, if necessary. This brief time also includes the commencement of dark adaptation.

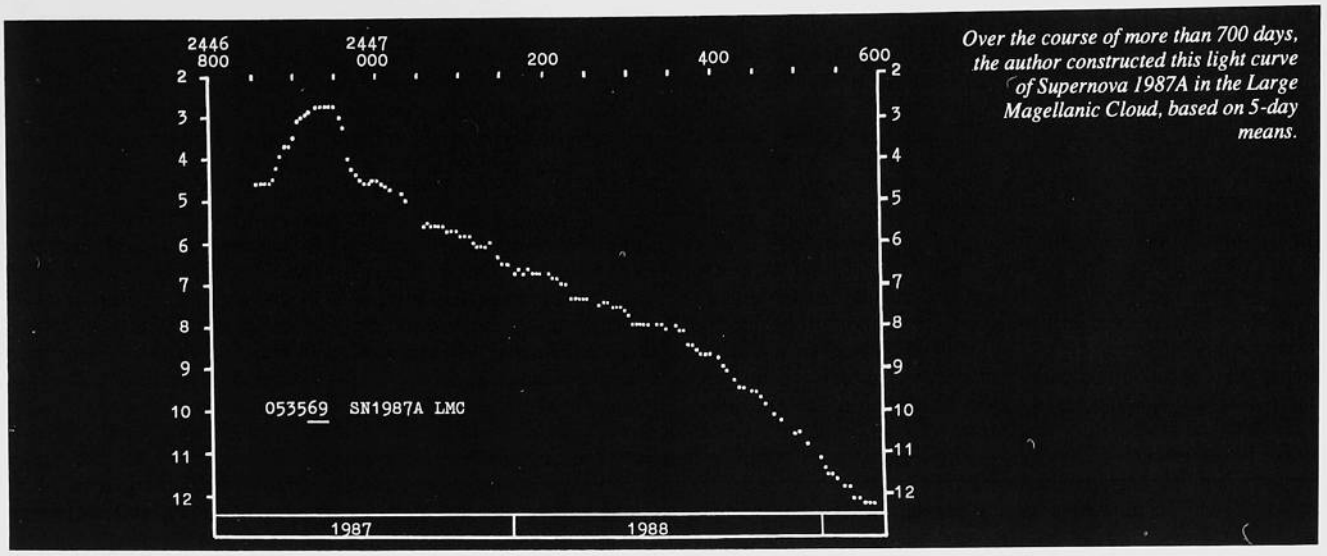
Dark adaptation itself is not a time to be wasted. A quick all-sky nova search to magnitude 3 or 4 can be accomplished in several minutes and has poten-



The author poses with his 12.5-inch f/6 reflector in Heathcote, New South Wales. With this instrument Peter Williams carries out an intense variable star observing program.



A light curve generated by the author for HDE 269858, a superluminous member of the LMC, shows the star's recent brightening.



Over the course of more than 700 days, the author constructed this light curve of Supernova 1987A in the Large Magellanic Cloud, based on 5-day means.

tial to reap great rewards — remember Nova Cygni 1975 (V1500 Cyg)? A binocular search to 8th magnitude follows in selected Milky Way fields according to season. These searches are carried out on virtually all clear nights, irrespective of Moon phase, with any suspect object being checked against reference charts based on *Atlas Australis*.

From my present observing site at Heathcote, New South Wales, some thirty kilometers southwest of Sydney, the naked-eye limiting magnitude is about 5.4. This is better than for most city dwellers but far from perfect. Based on fields that have reliable V-magnitude sequence stars, the 6-inch reaches between magnitude 13.0 and 13.5 on most nights, depending on conditions, elevation of the field under observation, and observer fatigue. Full Moon can reduce this limit by up to two magnitudes.

An observing session can be anything from ten minutes with binoculars to several hours at the telescope and most often commences a little after the end of evening twilight. It requires much more effort to work the morning sky without the stimulus of a bright nova, comet, or the like.

A typical night will begin with the naked eye, then binocular nova searches, followed by up to a dozen binocular variables. Eruptive and unusual stars are then checked and finally the red variables. Occasionally, individual stars will be observed out of sequence as they move toward conjunction with the Sun or a sudden cloud over occurs. A brief observing session of thirty minutes will consist only of a nova search, observation of special program stars, and monitoring some eruptive and unusual stars.

During periods of bright Moon, individual stars are naturally omitted from an observing session if their maximum light is less than the threshold magnitude of the telescope. The three eyepieces I use yield magnifications of 48x, 96x, and 140x with field diameters of 50', 21', and 15', respectively. The eyepiece employed depends on the brightness of the star under observation. The lowest practical magnification is used to obtain the largest field diameter.

For well-known fields (and particularly when the variable is below the visible threshold), observations can proceed at the rate of one per minute. But this can slow to several minutes per observation when star hopping to lesser-known or difficult to recognize fields is necessary.

As a guide to weather conditions in the Sydney area, observations were obtained on 154 and 158 nights during 1987 and 1988 respectively, but such figures are somewhat subjective.

With few exceptions the variable star charts used are obtained at nominal cost through Astronomical Research Limited, acting on the behalf of the VSS, RASNZ. These are issued as "Charts for Southern Variables" Series 2 through 20. Each series contains about fifty charts and covers a similar number of stars. Naturally, these sets concentrate on variables south of the celestial equator. Series 1 charts are included in Frank Bateson's instruction manual, *The Observation of the Variable Stars*. To protect the original charts, I always use photostat copies at the telescope and store the originals safely indoors.

There are almost as many systems of arranging charts for use at the telescope as there are observers. My system is straightforward: charts within a looseleaf folder are divided into two sections: the first for eruptive and unusual stars and the second for red variables. Within each section, stars are arranged in right ascension order, which also provides for a general sequence of observation. A second folder holds charts covering stars suitable for binocular observation, while the observations are recorded in a third folder.

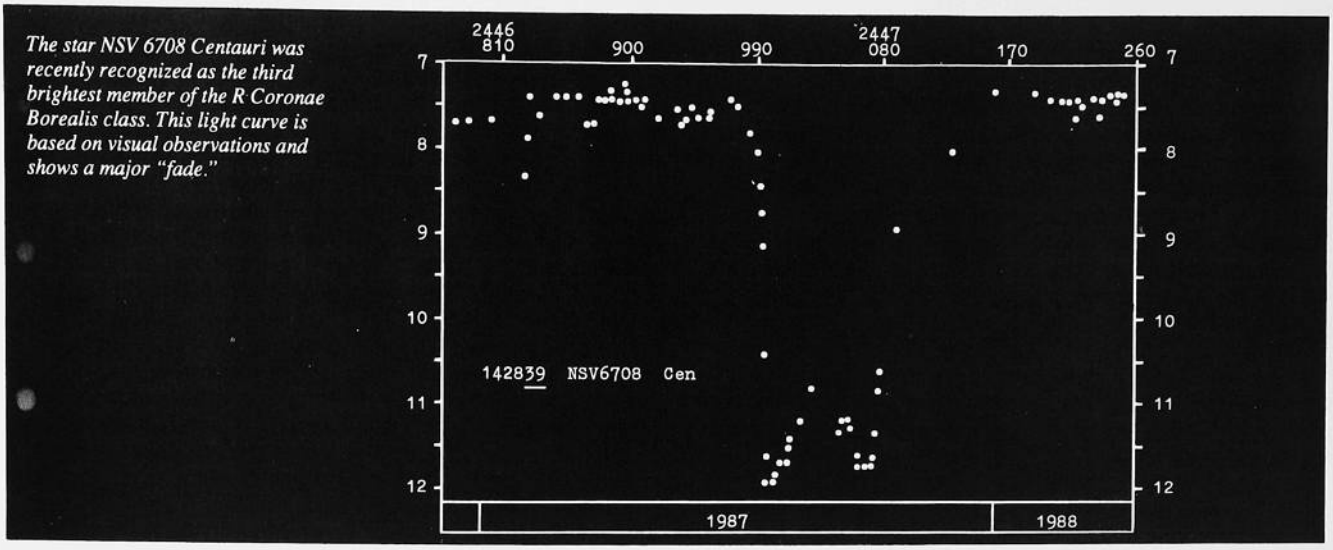
Julian dates to either two or four decimals, depending on the star in question, are determined at a later time; then the observations are transferred on to permanent record sheets for each individual star. This allows for correction or deletion of any obviously erroneous records prior to submission of monthly reports.

When submitting reports, the stars observed during that month are arranged into four groups: dwarf novae; novae and supernovae; irregular and unusual stars; and red stars. These are copied directly from the permanent record sheets that are always kept in strict order. Within each of the above groups, stars are arranged in right ascension order according to their Harvard Designation, and the reports are airmailed by the 10th of the following month for collation with results from other observers.

At present, there are 140 stars on my working list; individual stars are added or dropped according to taste or following requests from various international cooperative programs. These programs are arranged at the request of professional observers and operate in much the same way as those more recently introduced through the AAVSO. Obervations usually take the form of close monitoring of a specific number of stars or class, such as the UG stars. Advice of activity detected is phoned to Headquarters, who then relay the information to the interested professionals. These programs often involve satellite-based observatories such as the venerable *International Ultraviolet Explorer*.

Other current long-term programs include the early detection of declines in RCH stars and bright outbursts of the unusual UG stars BV Centauri and EX Hydrae. Advice of these programs and feedback is provided through monthly circulars, newsletters, and annual publications of the VSS and RASNZ.

IAU Telegrams and Circulars are the most common source for alerting observers worldwide of new discoveries or unusual stellar activity. The value of such advice, however, is degraded somewhat if there are no follow-up observations. Having recognized this a number of



The star NSV 6708 Centauri was recently recognized as the third brightest member of the R Coronae Borealis class. This light curve is based on visual observations and shows a major "fade."

years ago, Mati Morel of Rankin Park, New South Wales, instigated a system whereby reliable preliminary charts are sent to selected active observers in Australia and New Zealand, usually within twenty-four hours of an announcement. This allows for immediate and long-term visual coverage.

These excellent charts and all recent Series of Charts for Southern Variables are produced by Morel, whose personal library contains extensive resource material on published photoelectric V magnitudes. An informal Australian telephone network also has evolved for relaying discovery information or for seeking confirmatory observations where necessary.

As with deep-sky observers, variable star observers also have favorite objects for one reason or another. I am no exception and have an interest in obtaining regular observations of several recently recognized variables and stars whose long-term behavior is unknown. Of course, this may involve following a star for many years with little or no variation occuring. You may also find yourself providing only a long series of negative observations because the variable is never seen, as in the case of suspect recurrent novae.

One of my favorite stars is HDE 269858, a superluminous SD-type star of spectral class Ofpe, associated with a compact star cluster within the LMC. Not a great deal is known about this star, which makes it all the more interesting to follow. It was added to my working list in 1983 following professional interest in this type of variable and receipt of a preliminary chart. While such stars generally vary little over long periods of time, some do show slow periodic changes, and all are considered potential supernova candidates. They are therefore important astrophysical objects. Monthly mean brightness calculations of this star show a gradual overall brightening by almost two magnitudes during the six years of observation (shown in the accompanying light curve).

HDE 269858 is currently the brightest of six LMC members on my working list and at the time of writing is at a brightness comparable to the standard luminary S Doradus. HDE 269858 is situated in an easily located and most interesting field only 26' southwest of NGC 2070, the Tarantula Nebula. As it happened, Heathcote was clouded out during February 20 to 25, 1987 when SN 1987A erupted only 15' northwest of HDE 269858 (we all have tales of the one that got away). It is fitting, however, that Albert Jones of Nelson, New Zealand, the world's most prolific variable star observer and the only other individual who at that time regularly monitored this field, spotted and reported the interloper and is thus credited with a codiscovery of this remarkable object.

SN 1987A is perhaps the single most written about star of recent times, and rightly so. As the first naked-eye supernova detected since the invention of the telescope, it has provided astronomers with an unprecedented opportunity for detailed and long-term study of a nearby event. Fortunately, for some of us, this object occurred at a far southern declination. It is, in fact, a circumpolar object from Heathcote. This has enabled continuous monitoring during the two years since discovery, as is shown in the accompanying light curve.

Those early weeks after discovery were both exciting and confusing. The experts said it would fade, but the supernova continued to brighten. First it was a Type II, then a Type I, then a Type II again, and now in a class of its own. After a short time there was a certain degree of confidence regarding the progenitor star. This is the first time that information, though limited, has been available on a star prior to its eruption as a supernova.

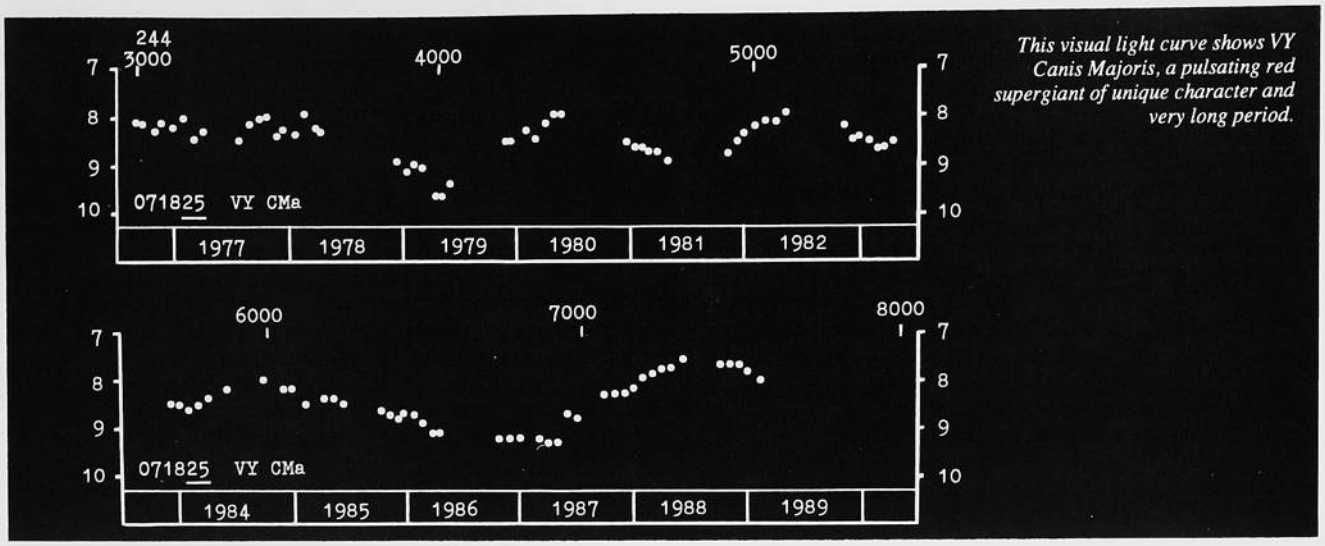
The popular choice for the progenitor is SK -69°202 (CPD-69°402), a blue supergiant of spectral class B3 II, which has no formal record of variation. It is the brightest member of a tight cluster. Magnitude and color values for this star were V = 12.24, B-V = +0.04, and U-B = -0.65. Time will verify this as the supernova fades to or past this pre-outburst level during 1989 and 1990.

At peak brightness during the latter part of May 1987, SN 1987A was an easy naked-eye object even from relatively heavily light-polluted inner-city areas. During that time it was actually possible to obtain a magnitude estimate while walking home from the railway station after work. All the more intriguing is the realization that you were comparing an object from another galaxy to stars within our own Galaxy with the naked eye.

SN 1987A remained a naked-eye object from Heathcote for 21 weeks, after which 10x50 then 20x80 binoculars allowed a further 65 weeks of coverage as it faded between magnitudes 5 and 10. Telescopic observation will continue until it fades below the threshold of the instruments available.

A rarely reported feature of SN1987A is the delightful color variation exhibited as the cloud of ejected material expanded and its temperature changed. For several days following the initial rise, it remained a clean, white color in line with its extremely high energy and rapid expansion. By late March, as the expanding shell continued to plough into the dense interstellar medium, the color changed to a golden yellow. Continued expansion saw this golden hue become orange-yellow at maximum light, then gradually fade again through pale orange to white as it reached 8th magnitude, the approximate limit of color detection with the 6-inch reflector. These color changes are somewhat typical of those exhibited by many of the brighter galactic novae.

The tale of NSV 6708 Centauri is typical of a successful and genuine amateur contribution to astronomy. Originally reported in 1964 as a suspect variable of small amplitude on photographic survey plates, it was forgotten until 1971 when it was again reported by New



This visual light curve shows VY Canis Majoris, a pulsating red supergiant of unique character and very long period.

Zealand amateur Ron Welch only to be again soon forgotten. Finally, in July 1986, Glenn Dawes of Kings Park, New South Wales, noted it during his photographic nova patrol. Preliminary charts were soon distributed and regular monitoring commenced.

After remaining near maximum light for eleven months, a rapid decline commenced. NSV 6708 faded 4.6 magnitudes in 23 days. It then fluctuated between magnitudes 11 and 12 for 74 days before recovering to maximum in 93 days. This was a particularly exciting fade because it was the first time that such an event was observed as a "real time" event.

Following this demonstration of its light variations, shown in the accompanying figure, and through the effort of Rob McNaught of the UKST at Siding Spring, the professional astronomical community began serious investigation of this star. Subsequently, research at Mount John University Observatory in New Zealand and the South African Astronomical Observatory has confirmed that NSV 6708 is a hydrogen-rich member of the RCB class. Amazingly, at maximum magnitude of 7.5, this is the third brightest star of the class, behind R CrB and RY Sgr.

VY Canis Majoris is one of the many variable stars on my working list found by offsetting from a notable deep-sky object, in this case the delightful open cluster NGC 2362 centered around the 4th-magnitude star Tau Canis Majoris. It is classified as a variable of unique type, a slowly pulsating red supergiant of spectral class M5 Ib.pec showing cyclic variations on a time scale from 200 to 1,900 days.

Lying only 1.2° southeast of NGC 2362, VY CMa is considered a possible outlying member of this young cluster, which, if correct, indicates it to be the most massive member of NGC 2362 to evolve to the red giant phase. If so, it must have reached this state very quickly indeed — in perhaps as little as 1 million years. This would support the belief that such stars do evolve very quickly, because red supergiants are exceedingly rare in young star clusters.

VY CMa has been subject to considerable mass loss, resulting in the formation of an extensive circumstellar envelope. Large telescopes show it as nonstellar in character due to the presence of this expanding and variable dust nebula. Double star observers may be familiar with this system through the alternative designations 78 Canis Majoris or ADS 6033. The American astronomer Thomas Jonathan Jackson See reported faint companions at 0.6" (p.a. 200°), 2.8" (p.a. 291°), 3.0" (p.a. 14°), and 6.9" (p.a. 30°), all of which are now believed to be condensations within the expanding nebular shell.

This associated nebula is recognized as a strong source of infrared radiation and of maser radio emission (OH, H_2O and SiO). The maser emissions apparently result from absorption of infrared radiation and subsequent re-emission by molecules in the dense dust nebula.

There also appears to be evidence of correlation between mass ejection and the continuous formation of solid particles within the circumstellar envelope. These particles, which are the prime source of the observed infrared emissions, do not fall into the central star because the radiation pressure is far greater than the gravitational attraction. VY CMa has a luminosity on the order of 30,000 times that of our Sun with a mass currently estimated at several times as great. Estimates of the nebula mass suggest that between one and two solar masses of material has been ejected from this star.

The light curve reproduced with this article is based on monthly means and only hints at the leisurely long-term behavior of this star. Twelve years of observation is clearly too short of an interval for meaningful results; a situation typical of many variable stars currently under observation. Unfortunately, the only way to overcome this situation is continued observation of these interesting objects.

Apart from regular variable star work, I often take time to enjoy some deep-sky observing and, to date, have accumulated detailed descriptive notes through the 6-inch reflector for over 2,200 objects visible from latitude 35° south. These notes form part of a systematic survey of objects to about 40° north declination commenced in earnest during 1983 and cover all types of objects: galaxies, open and globular clusters, bright and dark diffuse nebulae, planetary nebulae, multiple stars, plus colored and variable stars. Another several hundred objects, mostly multiple stars, remain to be observed as time permits.

As a member of the Sutherland Astronomical Society, based in the southern suburbs of Sydney, access is readily available to the society observatory, which houses a 16-inch f/6 Newtonian. Despite the relatively poor sky conditions at that site, stars to magnitude 14.5 can be reached on most nights and to 15.5 on rare nights of above average seeing. Extended objects such as galaxies and nebulae suffer far greater than stellar sources.

The society publishes a bimonthly newsletter, *Southern Observer*, to which I have been a regular contributor for fifteen years, penning articles on both deep-sky observing and variable stars. This newsletter is sent to all other societies in Australia on an exchange basis and to several overseas groups. These writings are geared at dispelling the misconception that a large telescope is necessary to obtain satisfactory views of many objects or to obtain scientifically useful observations.

Above all, however, the theme of enjoyment from observing is central, because that is the foundation on which amateur astronomy is based.

Peter F. Williams is an experienced observer living in Heathcote, New South Wales.

Deep Sky Reports
The Story of Novae
by Peter Collins

It was Saturday evening, September 9, 1978. I was standing in twilight near a small storage shed at the Fred Whipple Observatory on Mount Hopkins, Arizona. I had a pair of 11x80 binoculars on a photo tripod and was looking out toward the horizon, hoping to spot a comet appearing from around the far side of the Sun. A waxing gibbous Moon hung high in the sky, so it was the only comet hunting I could do until the wee hours of the morning.

For the remainder of the moonlit evening, I would make variable star observations and pursue my new program, a visual search for novae with binoculars. Richard McCrosky, a visiting scientist from the Harvard-Smithsonian Center for Astrophysics, saw me and said, "Frances Wright's the one who should make that kind of discovery." She had searched photographically for comets in twilight years earlier at Harvard's Agassiz Station in Harvard, Massachusetts, where McCrosky was now the resident director.

I began this program less than a year before, and it simply involved sweeping that part of the Milky Way I had already memorized, looking for an interloper in the star fields. Such an interloper could be a mistake or uncertainty in memorization, a variable star, a minor planet, or conceivably a more unusual event — a spasm of embracing stars, a galactic nova. The sweeping program was low-key, rather pleasant, and the last place I would have expected some kind of success on that particular night.

Rather late, at about 11 p.m., I began sweeping for novae using my 7x50 binoculars. I swept through Aquila, Delphinus, and Sagitta, learning one or two little star groups as I went. Then I headed up into Cygnus, and further up toward northeastern Cygnus and Lacerta, now riding high in the northwest.

I was sweeping along a long chain of stars that leads out to the popular variable star SS Cygni, when something peculiar happened. I saw two stars on the outer edge of the region where normally I only saw a single star. Unlike most of my nova suspects, this new object, at about 7th magnitude, was so compelling that it demanded to be looked up in the atlas at once.

At this point, I began a procedure to verify that the object was actually a nova. This took an hour or so, and I kept Dick McCrosky posted on the situation. We eventually decided it was real enough to take a spectrogram and notify Agassiz Station on the East Coast to take a plate for verification before the object set. By the end of the next day, an announcement telegram had been issued by the Central Bureau for Astronomical Telegrams in Cambridge, and I knew what it felt like to have discovered something!

Life is seldom as simple as it first seems. A number of other observers had also discovered this object, and one of them, Warren Morrison of Peterborough, Ontario, had beaten me by about six hours. The nova, officially Nova Cygni 1978, was only about 40 arcminutes from the very popular variable SS Cygni, so many people observing SSCygni picked up the nova as well. Because of a delay in sending telegrams, I did not find out about Warren's discovery until the following Monday. I was not terribly put out by the news — I had thoroughly sampled the experience of discovery and had demonstrated the validity of my program.

I went on to make my own "first discovery" of a nova in Vulpecula just before Christmas in 1984, when I was living in California. This was accomplished with 11x80 binoculars. A third discovery came in November 1987, again in Vulpecula. This star's first discoverer was Reverend Kenneth Beckmann, chair of the AAVSO Nova Search Committee. I picked it up two hours after Backman.

Warren Morrison also scored again. In January, 1985, he made the first observation of an outburst of the recurrent nova RS Ophiuchi.

Way back in the 1950s, when the Palomar Sky Survey was made, Nova Cygni 1978 (V1668 Cygni) was a 20th-magnitude star about 4,000 light-years distant. The star was a binary, and a close one at that. One star of the pair was a compact, probably bluish object, perhaps like the central star of a planetary nebula, and the other a distended red giant. The giant was so large, and the stars so close, that portions of its outer envelope were drawn on to the smaller star. The red giant eventually expanded to fill its so-called Roche lobe, the portion of space gravitationally bound to itself rather than its neighbor.

Because of the mass transfer continually going on, a circular disk of hot gas called an accretion disk formed around the compact star. Although the exact details have not been fully elucidated, some of the gas in the accretion disk, mostly composed of hydrogen, probably then fused rapidly into helium, releasing a great deal energy. (The phenomenon can be very roughly compared to the explosion of a hydrogen bomb.) This is what produces the outburst we call a classical nova, a brightening of the star. In this typical case, the star jumped in brightness by fourteen magnitudes. The system is not destroyed. The nova outburst, unlike supernova outbursts, does not radically change the host system.

There are many examples of this close binary model in variable star astronomy. SS Cygni is such a system and is classified as a dwarf nova, or U Geminorum star. It has small outbursts of about four magnitudes every twenty to one hundred days. Classical novae are also thought to be periodic in nature, recurring over thousands of years. Bridging the gap between classical and dwarf novae are "recurrent novae," stars that recur in historical time frames. A good example of this type of star is T Coronae Borealis, which erupted in 1866 and 1946, rising from 10th to 2nd magnitude each time.

It seems that the intensity of the outbursts increases with the period. The light curve of these outbursts is always about the same: a sharp rise to maximum followed by a slower descent (which for classical novae takes years) to the original magnitude. A classical nova outburst can be classified as slow, moderate, or fast, based on the time scale of the descent. The faster the descent, the greater the intrinsic brightness of the nova. There is also a common tendency to idiosyncrasy. Some classical novae, such as Nova Delphini 1967, have very rambling light curves following the initial rise.

The equipment needed for nova searching is modest: a pair of binoculars (I use 10x50s), a star atlas, and other reference materials. The observing requirements are to conduct a patrol every clear night, but the observing site need not be world class. As long as you can comfortably reach your limiting magnitude, you'll do fine.

Where are novae found? The accompanying map shows the distribution of novae that have been discovered in the sky visible from mid-northern latitudes. Note the clustering of novae toward the Milky Way and especially the rich grouping of novae around the galactic center region in Sagittarius. Notice many of the novae in Sagittarius are faint, which makes sense

Novae are exciting events to watch: during the last days of August, 1975, Nova Cygni flared by many magnitudes and could be observed with the naked eye. The photo at left was made on August 30, 1975, the one at right on October 8, 1975. By then the nova had faded to invisibility. Photos by Jean-Guy Moreau (5-inch f/5 reflector, 103a-F film, 6-minute exposures).

because they are not only far away (10,000 to 30,000 light years) but are obscured by interstellar dust.

It's not entirely clear to what extent the relative poverty of the winter sky is due to a "selection effect." The fact that it's harder to observe in winter and it's considered a poor area to find novae may account for the lack of winter discoveries.

Suppose you want to start a visual nova program. Begin your program by memorizing fields at some convenient point in the Milky Way. It was George Alcock who first showed that this was possible. How do you memorize all that? My own experience suggests it will be easier than you think. The night sky is far more distinctive than ink dots on a paper star atlas will ever be. The approach to memorization is the time-honored one, finding and naming distinctive star groups among binocular star fields.

Because you won't always work under identical conditions, consider the question of limiting magnitudes. Normally, I don't try to memorize everything I can see. I pick a limiting magnitude and identify some stars near that magnitude. I may use a variable star sequence to pin this down more precisely. The limiting magnitude for the nova patrol (typically 8th magnitude) should be a magnitude or so brighter than the limit of what can be actually seen in the binoculars. In my present semi-urban environment, 10x50 glasses achieve this fairly well, falling a little short near the southwestern horizon or in bright moonlight.

What if you find something? Suspects are common enough — I usually get three or more per night. A nova searcher typically has a "first line" star atlas to cover most of these. A good choice might be *Uranometria 2000.0*, which has a decent set of star disk sizes and is a convenient size for reproduction. If you're going to 8th magnitude, Tirion's *Sky Atlas 2000.0* works well. If you have access to the right equipment and databases, it is quite feasible to produce your own custom atlas.

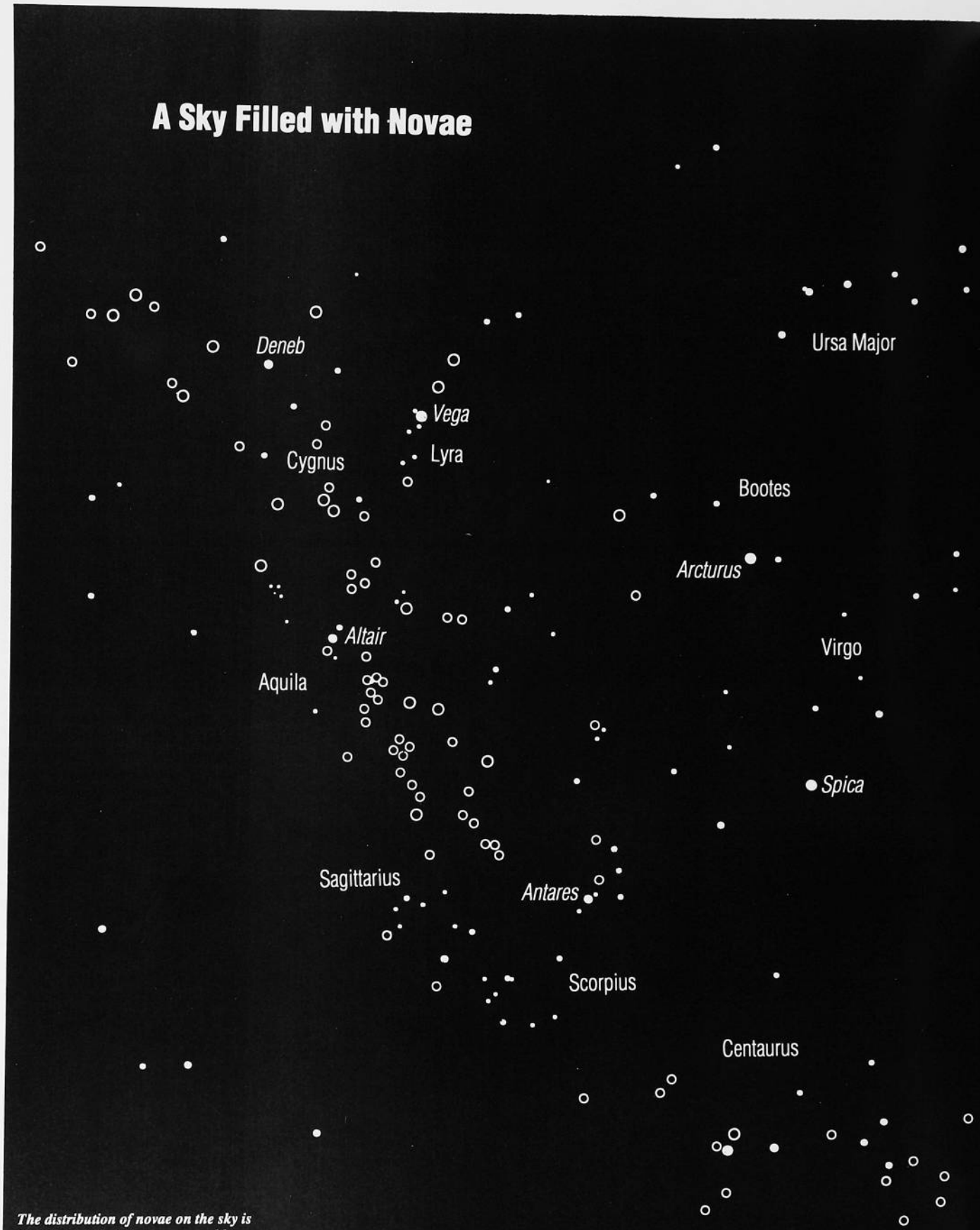
If the suspect is not on the first-line atlas, the next step is to go to a photographic atlas and check against possible omissions on the main atlas. If the star is not there, it is probably either a known variable star, a minor planet, or an unknown variable star such as a nova. To check these possibilities, try to get as accurate a position as possible, using something larger than a pair of binoculars.

This is also a good time to play "devil's advocate" — trying to find a possible field misidentification. The *AAVSO Atlas* nearly completely charts variables that brighten above magnitude 9.5, so you might check that first. Two Soviet publications, the *General Catalog of Variable Stars*, and the *Catalog of Suspected Variables*, serve as a last word on the subject. These catalogues may be purchased from AAVSO headquarters.

Minor planets can be very conveniently checked using the computer service provided by the Central Bureau for Astronomical Telegrams or ephemerides published in such places as the *Observer's Handbook* of the Royal Astronomical Society of Canada. Be careful, however, because some publications only carry ephemerides of minor planets near opposition. If you have an hour or more to play with, you could always check for motion. This option is not always possible, as I found out this March when I "discovered" Vesta ten minutes into dawn.

If all these checks pass and you think you have discovered a nova, notify the Central Bureau

A Sky Filled with Novae



The distribution of novae on the sky is hardly smooth: A map generated by Peter Collins shows that by far the greatest number of novae occur in the summer Milky Way.

for Astronomical Telegrams. You should also notify the AAVSO by calling (617) 354-0484. It is important to have the earliest possible spectroscopic and other professional-class observations of novae, so it is desirable to report as early as possible after you are confident of your observation. You should be able to report your discovery within a few hours of making it, if you are properly prepared. But be careful: an erroneous report leads to hours of work on the part of observers trying to verify the object and will be to the detriment of the reputation of the reporting observer.

The AAVSO has a Nova Search Committee, which organizes and records the efforts of visual nova searchers. Participating in the work of this Committee allows the record of your patrols to be part of an overall data bank, helping to improve our knowledge of the statistics of nova distribution. The Nova Search Committee has divided the sky into numbered search regions and assigns some of these regions to each observer. There are also regions searched routinely by everyone. To find out about the AAVSO program, write to their headquarters at 25 Birch Street, Cambridge, MA 02138.

Visually scanning the sky is not the only way to find novae. Photographic methods are widely used and actually help uncover the majority of novae at this point in time. I find visual scanning more satisfying for its simplicity, and the kind of self-cultivation it requires.

When recalling my last eleven years in the nova effort, two things strike me. First, it's amazing that visual searching has uncovered a relatively small number of novae. Second, when they do occur, multiple visual discoveries seem to be the rule. For each of my discoveries, someone either preceded or followed me with an independent discovery within a day or two. Therefore, I feel that nova searching is an active competitive field in which dedicated amateurs can make a great contribution to science.

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Deep Sky Reports
A Parcel of California Galaxies
by David J. Eicher

Two important names in the current upswing in astrophotography are Hallas and Mount. No, they're not a law firm. Rather, Tony Hallas and Daphne Mount are a couple who live in Oakview, California. Over the past year or so they have produced some of the finest amateur astrophotographs I've ever seen.

Tony and Daphne have at least one distinct advantage over most astrophotographers — they own their own custom photo laboratory in Ventura, California. This allows them to tweak and adjust the developing and color balancing processes to maximize the quality of their negatives. However — because they're black-and-white images — the galaxies shown on these pages strongly reflect what Tony and Daphne are recording "straight out of the sky."

Typically, Tony and Daphne use either a 14-inch f/10 SCT, usually stopped-down to f/7, or a 5-inch f/8 Starfire refractor. Sometimes, however, they piggyback a telephoto lens and shoot large deep-sky objects (see the contents page photo). All of the photos shown here were made using hypersensitized Tech Pan film.

You'll certainly see more of Tony and Daphne's work in future issues. For the moment, enjoy the magnificent detail captured by Hallas and Mount in this parcel of California galaxies.

Graceful spiral arms, knots, and HII regions characterize the galaxy M101 in Ursa Major. All photos in this article are by Tony Hallas and Daphne Mount and were made with a 14-inch SCT at f/7, hypersensitized Tech Pan, and 60-minute exposures.

M81 in Ursa Major shows dust lanes, a strikingly bright nucleus, and low surface brightness arms in this 60-minute exposure.

Top: Hydra's M83 is one of the finest face-on galaxies in the sky. The galaxy's barred spiral arms contains knotty patches of light that represent HII regions and huge star clouds. Above left: Interacting galaxies NGC 4038 and NGC 4039 in Corvus show faint luminous arcs extending outward from their bright centers. Above center: The Whirlpool Galaxy (M51) has arms that loosely wrap around the galaxy's hub: intruder galaxy NGC 5195 lies just north of the Whirlpool. Above right: NGC 4725 in Coma Berenices is a barred spiral that has a double ring of material on the outer edge of its spiral arms.

Deep Sky Reports
Reader's Page
by Steve Coe

Pegasus is a constellation that offers challenges for any deep-sky observer. It contains lots of dim galaxies and few stars to guide telescopes by necessitating a good star atlas like *Uranometria 2000.0*. I also recommend using a large finder scope for searching out deep-sky objects in a constellation like Pegasus. On one of these cool autumn nights, take a look at Pegasus and see what it has to offer.

NGC 7448 is a pretty bright galaxy, is fairly large, and is elongated by a ratio of 2:1. This object has a very bright nucleus measuring about 10" across.

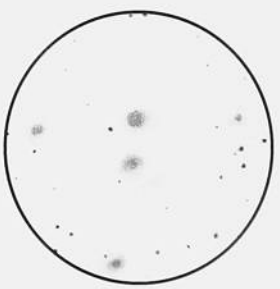
NGC 7454, another galaxy, is faint, pretty small, round, and somewhat brighter toward the middle. A bright star lies along one edge of this unusual galaxy.

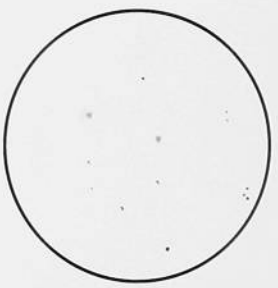
NGC 7469 is a faint galaxy that is somewhat elongated and not at all brighter in its middle. It was just visible in my 13-inch scope at 100x, and higher powers did not seem to help.

Galaxy **NGC 7479** is a bright and large object, elongated 4:1. It has a high surface brightness core about 20" across at 165x. High powers show that this object is an attractive barred spiral with a fair degree of visible structure. The bar measures about 5' long and each end has a curved glow attached. To me this object looks like a two-arm garden sprinkler. Averted vision makes this galaxy grow in size appreciably.

NGC 7619 marks the center of the Pegasus I Galaxy Cluster. Five other galaxies lay scattered across the same field at 100x. All of the others are dimmer than NGC 7619 and also appear as roundish smudges of faint light. Within one degree of the cluster's central portion lie six other galaxies, several visible only with averted vision.

Reader Brent Archinal of Falls Church, Virginia, sent in the following descriptions of assorted objects in Pegasus.



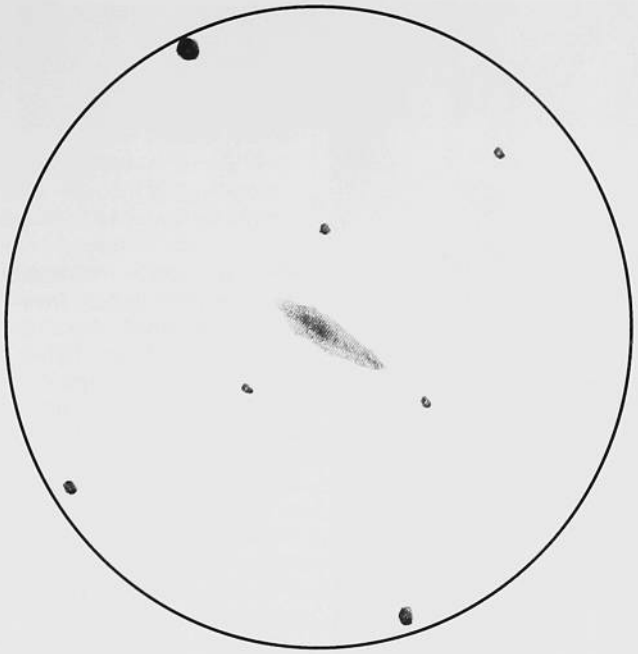


Above: The barred spiral galaxy NGC 7479 is one of the brightest objects in Pegasus. Steve Coe sketched it using a 13-inch f/5.6 reflector at 80x.
Right: Filled with tiny fuzzies, the Pegasus I Galaxy Cluster is a challenge for keen-eyed observers. Steve Coe sketched its center with a 13-inch f/5.6 reflector at 100x.
Far right: A.J. Crayon sketched the Pegasus I Cluster with an 8-inch f/6 reflector at 80x.

NGC 7448: Viewed with the 32-inch scope at low power, this object is clearly a spindle-shaped spiral galaxy. Nucleus well spread out. Reminiscent of a dim M31. Situated 1/3 of the way between two approximately 10th-magnitude stars. Elongated mostly north-south.

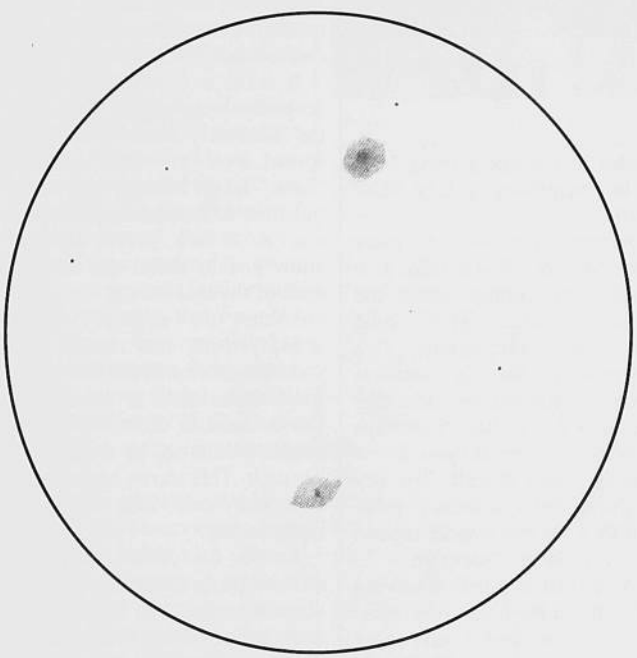
NGC 7479: Viewed with the 32-inch scope at low-power, this galaxy is very extended. It is mostly situated between two equal 13th-magnitude stars, although the nuclear area appears elongated (or barred?) north-south. This object took me a while to find, as it appears to be misplotted on Vehrenberg's *Handbook of the Constellations*. It was not visible in the 4-inch Clark finder scope.

NGC 7619: With the 32-inch at low power, this galaxy is faint and elongated, clearly an edge-on specimen. The galaxy's dimensions are about 2' by 0.8'. A 7th-magnitude star lies just south of the galaxy. The 4-inch Clark shows several stars not visible in the main telescope. The double star at left in the drawing was also visible in the



Brent Archinal examined the galaxy NGC 7619 at low power with an extremely large telescope. His sketch shows the galaxy in a 32-inch Cassegrain reflector at what he calls "low power."

Dennis Caspar sketched the galaxy NGC 7479 with a 13.1-inch f/4.5 scope at 143x.



Galaxies NGC 7619 and NGC 7626 appear as a pair in this sketch by Dennis Caspar, made with a 13.1-inch f/4.5 scope at 143x.

The odd-shaped galaxy NGC 7448 is clearly visible in this sketch by Dennis Caspar, made with a 13.1-inch f/4.5 scope at 143x.

finder scope.

NGC 7619 and NGC 7626: With a 12.5-inch reflector, this field contains twin galaxies, both about 3' by 2', separated by 10'. An 8th magnitude star lies just to the northwest. Both galaxies glow at about magnitude 11.5.

Here's a rundown of the constellations and objects that will appear in future columns. What we'd like you to do is send observations of these deep-sky objects to Dave, in plenty of time, so he can publish them in the magazine. You can use any telescope you want to, and don't worry about the artistic quality of the sketches.

Winter 1989-1990: Gemini. NGC 2392, NGC 2371-2, NGC 2266, NGC 2420, IC 443, and J900.

Spring 1990: Leo. NGC 2903, NGC 3098, NGC 3162, NGC 3185-93, and NGC 3226-7.

Summer 1990: Lyra. M56, M57, NGC 6703, NGC 6765, NGC 6791, and PK 64+15.1.

Autumn 1990: Andromeda. NGC 68 galaxy group, NGC 404, NGC 752, NGC 891, NGC 7662, and NGC 7686.

Dave will look forward to receiving your observations.

5942 West Loma Lane
Glendale, AZ 85302

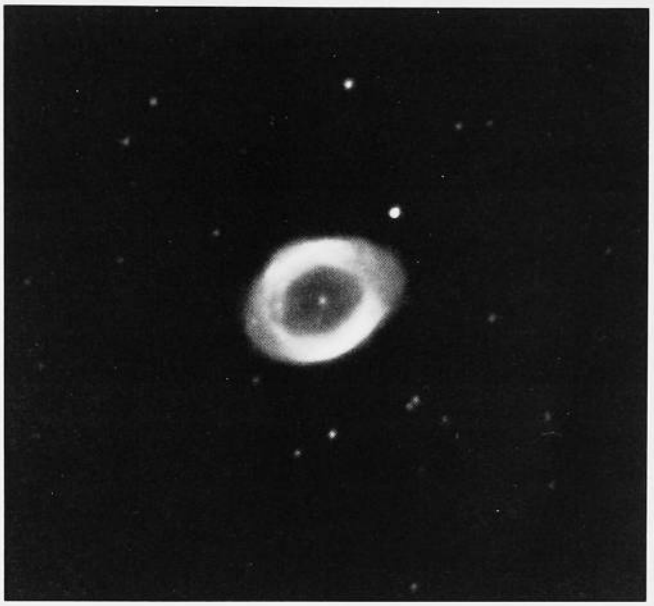
Small Scope Showcase
A High-Power Tour
by Alister Ling

Late summer humidity often obscures subtle details of objects in the Milky Way. At this time of year, the delicate dark nebulae in Sagittarius have disappeared, and the background sky seems a little too gray to search for low surface brightness galaxies and nebulae.

One way to beat the haze is to look at objects near the zenith. Only a thin layer of haze lies overhead; whereas a thick ring of muck hugs the horizon. Rather than resorting to observing only objects near the zenith, however, why not look at some objects with high surface brightnesses? These objects can suffer some light loss without losing their appeal. Furthermore, we can view them with high magnifications, which darkens the sky background and pulls out details that might go unnoticed at low powers.

Experienced observers may groan at the mention of **M13**, the Hercules Cluster (NGC 6205). Sure, it's a great globular cluster, but can't we move on to something different? I want to challenge you to gaze long and hard at M13. Rather than taking a quick peek, critically examine the cluster's details and get to know them by heart. Any backyard instrument at low power shows the familiar sight of an irregularly round ball of stars positioned at the vertex of an isosceles triangle formed with two equally bright stars. However, M13 has a spidery appearance that demands careful attention beyond the "big fuzzy ball."

Large scopes have no difficulties displaying two prominent star chains emanating from the cluster's center and traversing south and west. Two slightly fainter "arms" strike out in nearly opposite directions. This means that M13 is not as uniformly round as most other globular clusters. Owners of 4-inch scopes will need to employ high powers to see these features clearly.



M57, the famous Ring Nebula in Lyra, is one of the most attractive planetary nebulae in the sky. Photo by Kim Zussman (11-inch f/10 SCT, hypered Tech Pan film, 20-minute exposure).

At moderate powers we can cleanly resolve M13. One of the first things to notice is that the stars range smoothly in brightness — no two or three stars stand out from the others (as is the case with M5 in Serpens). Now try a power of 200 or more. This shows numerous fainter stars, which round out the cluster nicely. This magnification brings out faint star chains and dark spots, both of which seem to jump all over the cluster as your eye tries to take them in. If you stare at M13 for a minute or two, you may notice that the dark areas return to the same spots. The most prominent areas are the three lanes first observed in the mid-nineteenth century by Lord Rosse.

This seldom-seen feature is popularly known as the "propeller." The three dark lanes intersect at a perfect angle of 120 degrees, but not in the center of the cluster. Look off to the southeastern side about two-thirds of the way out from the cluster's center. The darkest arm points straight outward in a direction between the two bright field stars. It is also at right angles to the line joining M13 to its "neighbor," galaxy NGC 6207.

Almost opposite the center from the Lord Rosse lanes is a single lane cutting across the northwest edge. After some inter-scope comparisons, I've determined that the smallest aperture required for detecting the lanes is 5 inches, or perhaps a 4-inch scope if you know exactly where to look. The key to seeing this feature is to relax and let your eye wander around until it suddenly "locks on."

As a final step before leaving M13, boost the magnification as high as the seeing and your scope will allow. Don't be afraid to use a Barlow lens. The sight of innumerable stars pouring out of the field is truly remarkable, even more so if you're using one of the new generation of extremely wide-field eyepieces.

Another favorite object for summertime observers is **M57**, the Ring Nebula in Lyra (NGC 6720). M57 was the first non-stellar object I ever observed. Do you remember which Messier object you saw first?

With my trusty 4.5-inch scope I could pick up M57 from downtown Montreal. Once it became a familiar sight, I used M57's visibility to gauge the clarity of the sky. I soon noticed that once M57 dropped below 45 degrees from the horizon, it became progressively more difficult to see. This demonstrates just how quickly atmospheric extinction takes its toll on nebulous objects as you push your observing down to the horizon.

Although a nebular filter is not required to see M57 in country skies, a high-contrast filter might be necessary for people attending a suburban star party. The soft, gray-blue smoke ring is a strikingly symmetrical oval with an obviously dark central area.

It takes a 6-inch or 8-inch scope and a dark night to reveal the extremely faint nebulosity spread over the dark central "hole." In a 12-incher this central mist is immediately apparent. A 5-inch scope should allow you to detect the fainter ends of the major axis, showing you that the ring is pretty strongly oval, not round. Do you remember whether the central hole is round or elliptical? I'm inclined to think that most people would not be willing to bet on it. This shows how much observers can *look* without really *seeing*.

As for the central star, the critical factors determining its visibility seem to be high power and good seeing. The high power is necessary to fade the ring's central nebulosity so that the star can shine through. Every time I have spotted it, moments of good seeing made the star "pop" in and out, never holding steady. I know of only a handful of reports of the star's visibility in scopes smaller than 8 inches. As a first check, I always look for the faint star diagonally opposite the bright one on the western edge. If I can see that one easily, then the central star is probably visible.

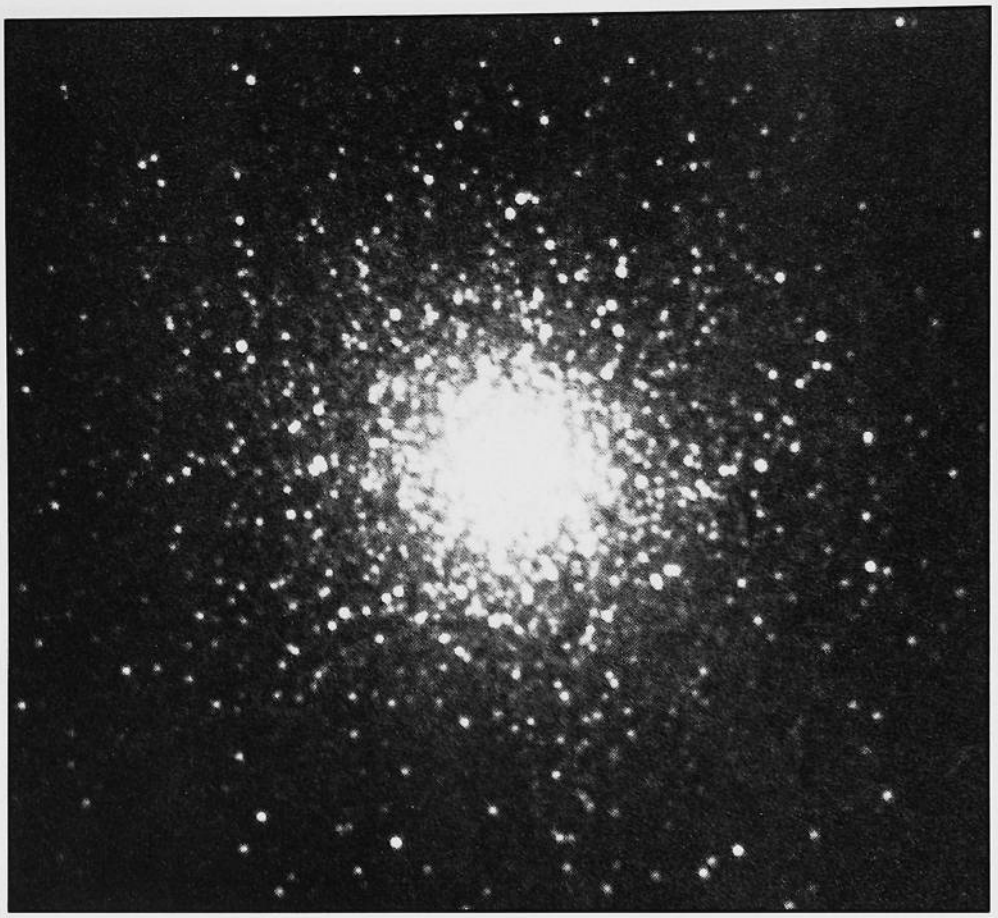
Want to make an observation that is difficult to make with a big scope? Swing your telescope to the northern reaches of Cygnus, where another favorite summer planetary nebula NGC 6826, the Blinking Planetary, lies. NGC 6826 is about as classic a planetary as you can get — a bright disk surrounding a very bright central star. In small scopes the nebula disappears if you stare at the central star directly. Bigger telescopes collect so much more light that the nebula is easily seen as green.

But many of you already know that. I want to draw your attention to the subtle detail in the disk itself. To glimpse this detail, you will have to use very high magnifications like 300x or more. Under the black skies of southern Alberta, NGC 6826 appears so bright that Tom Matty and I decided to push his 8-inch f/6 Newtonian to the limit. The seeing was rather steady and the images provided by his 4.8mm eyepiece were crisp, so we pulled out the Barlow to get 500x. Good thing we had a drive!

At such high magnification, the disk of NGC 6826 was quite dim and we were able to perceive a star located in position angle 300° about two-thirds of the way toward the nebula's edge. After considerably more study, we spotted another star exactly opposite the first but much fainter. We were elated to find out later that these corresponded to two slightly nonstellar blobs noted by H. D. Curtis in his 1918 study of planetary nebulae.

Curiously, I was unable to duplicate this observation a year later with a rather nice 20-inch scope. Consequently, I'd like to hear about observations or thoughts from anyone on this subject and the following hypothesis.

Can the eye more easily detect low-contrast differences when they are near the limit of visibility? The bigger scope with its greater light gathering power shows both the knots and surrounding nebulosity brightly with only slight differences and ratios. The smaller scope shows both as well, but the surrounding nebulosity has almost faded away, making for a greater ratio in brightness, rather than difference.



Above: M13, the Hercules Cluster, is the finest globular in the northern sky. Photo by Martin C. Germano (8-inch f/10 SCT, 103a-F film, 25-minute exposure). Right: Planetary nebula NGC 6826 is nicknamed the Blinking Planetary because only its central star is visible with direct vision. Photo by Jack Marling (24-inch f/15.2 Cassegrain, Fujichrome 400 film, 90-second exposure).

There are dozens of bright planetary nebulae scattered across the sky that are quite suitable for similar study. Why not drop *Deep Sky* a note about your successes (or failures)?

Located in the northern reaches of Cygnus away from suitably bright guide stars, lies the delightful open cluster **NGC 7128**. At low power this object appears as a nebulous patch measuring about 4' across. To best see it, move up to 150x or more. Three bright stars are involved with the group with a granular haze to the north. You'll need dark skies and extremely high powers to resolve the fainter stars.

With his 6-foot telescope, Lord Rosse commented that in NGC 7128 the "stars [are] disposed in pairs in a remarkable manner, one very red [star glowing at] about 12th magnitude." Any small scope at low power on a dark night will show unbelievably rich starfields in the neighborhood of NGC 7128, an object worth returning to again and again, especially after the Sagittarius region has set.

The best thing about Cygnus is that it never seems to set: with the day rapidly getting shorter, Cygnus crosses the meridian at twilight's end for two months, at least for those of us in the northern latitudes. Plan to spend some high-power time viewing its wonderful northern riches.

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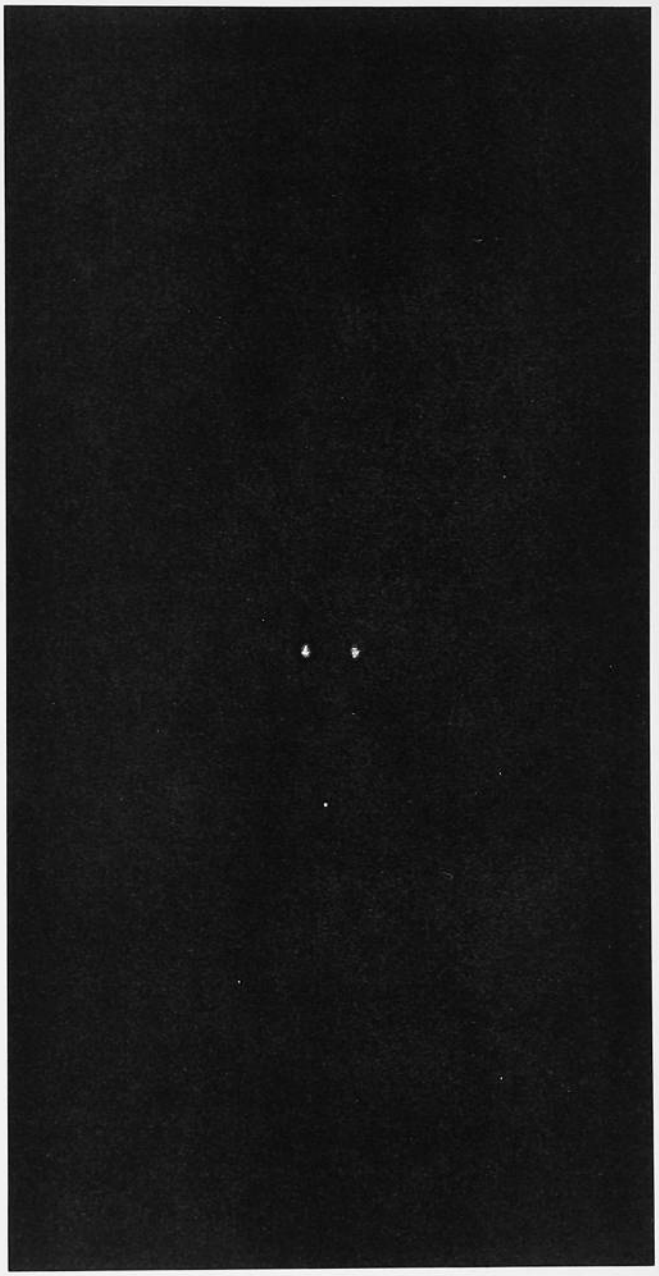
Double Stars
Delphinus and Equuleus
by Brian Skiff

It's been ten years since Glenn Chaple treated these two small autumn constellations in this column, so it's time for another look. The sample is based, as usual, on the double star listing in *Sky Catalogue 2000.0*, volume 2, and it is restricted to stars closer than about 10 arcseconds and with magnitude differences of less than about 3.0. The table below includes recently published data not available at the time the *Sky Catalogue* was prepared.

One of the nicest pairs anywhere in the sky is **Gamma Delphini** (ADS 14279), located at the snout of the stick-figure outlining the constellation. It is an easy pair for the smallest telescopes at low power. In larger instruments the stars take on a mild color contrast, comprising a yellowish K subgiant and a white F dwarf. The magnitude difference has been measured photoelectrically to be 0.92 magnitudes, providing a good reference for making Δm estimates for other stars. A true physical pair sharing a common proper motion, they have an orbital period in the range of 3,200 years.

In the same field to the south is the fainter, slightly closer pair **ADS 14270**, also a good object for small instruments. As with Gamma Delphini, I found them easy to resolve at 50x in my 6-inch refractor. I also found the magnitude difference to be similar, and photoelectric measures indicate a Δm of 0.83.

The brightest and most interesting pair in Equuleus is undoubtedly **Epsilon Equulei** (ADS 14499), actually a triple for telescopes of 5-inches aperture and larger. The easy pair (ABxC) has a 10" separation and is easy to locate at low power even in a 2.4-inch refractor. With first-class instruments of 3- to 4-inches aperture, the primary should look at least oval when using 200x or more on nights of good seeing. In 1986 I used the Lowell 24-inch Clark refractor stopped to only 6-inches and found the close AB pair resolved at about 400x, their Airy disks (0.85" diameter at this aperture) just separated. This summer I repeated this observation with the 6-inch refractor at 300x.



Composed of magnitude 4.5 and 5.5 stars separated by 9.6", Gamma Delphini is an easy pair for small telescopes. Brian Skiff photographed the star with Lowell Observatory's 24-inch Clark refractor stopped-down to 10-inches aperture. He used Kodachrome 200 film and a 1-second exposure.

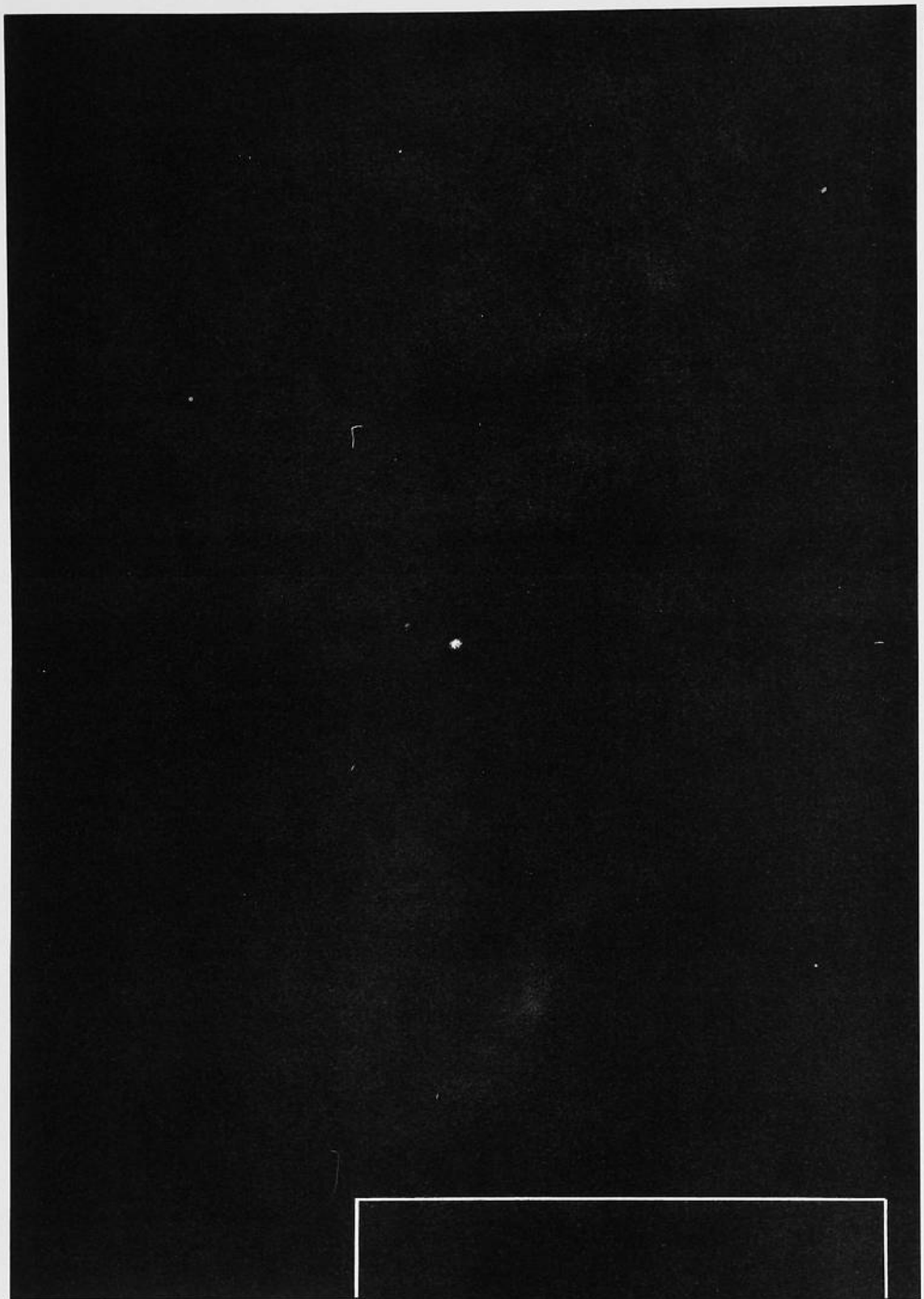
There are no other pairs in these two constellations with the visual interest of Gamma Delphini or Epsilon Equulei, but a good collection of others brighter than magnitude 8 are available for telescopes of all sizes. All three of the remaining pairs listed in the table under Equuleus were resolved in the 6-inch at 80x, a power I use for sweeping fields for moderately close pairs. **2 Equulei** (ADS 14556), the brightest of these, is listed with equal magnitudes in the *WDS*; I could see hardly any difference visually at high power. Yet the accompanying photo seems to show a substantial difference, which I estimate to be 0.3 magnitudes; perhaps one component is slightly variable.

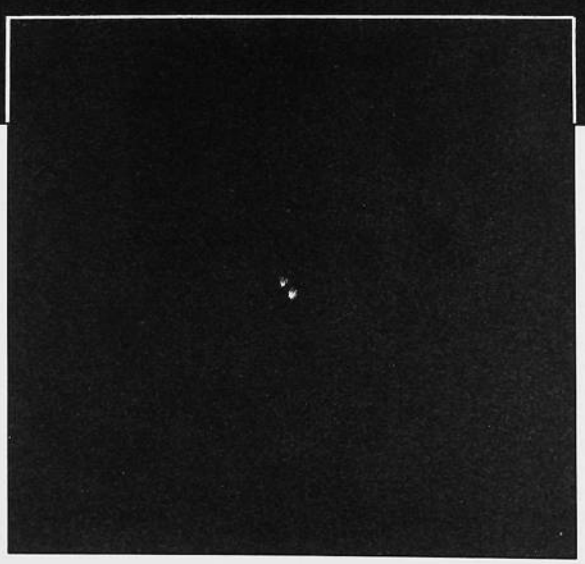
A variety of pairs exist in Delphinus, some of which are quite challenging for amateur instruments. The faint companion to **ADS 13688** was visible at 80x in my 6-inch, although it was just visible in the glare of the primary; higher powers provided a better view. The wide quadruple **ADS 13767** needs about 150x to pick up the closer, fainter AB pair, but just 50x will do for the wider CD pair.

On **1 Delphini** (ADS 13920), the close companion lay northwest of the primary inside the first diffraction ring at 300x. Even at this magnification, I could not detect the C component, supposedly 14th magnitude. I suspect it is at least a magnitude fainter.

ADS 14205 and **ADS 14209** lie in the same field. The first is much more difficult because of the faint companion, and I needed 300x for a good view. The other pair were resolved at only 30x.

ADS 14233 and **ADS 14238** also sit in another low-power field. Neither is an easy object for small apertures. This summer I found ADS 14233 pretty close in the 6-inch even at 300x; in 1986 I had a good view of the pair at 400x using the Lowell Clark stopped to 8-inches aperture. On these occasions, I estimated the Δm to be 2.0 and 1.2, respectively. As a result of earlier observers having suspected such shifts, Dick Walker of the U.S. Naval Observatory in





Above: Epsilon Equulei consists of a close A-B pair and an AB-C pair that is resolvable in small instruments. Skiff's photo, made with the Clark refractor stopped-down to 16-inches, shows the AB-C pair. The components shine at magnitudes 5.2 and 7.1 and are separated by 10.6". Skiff used Kodachrome 200 film and a 1-second exposure. Right: The close double 2 Equulei is an equal pair (magnitudes 7.4 and 7.4) separated by 2.8". Skiff photographed the pair using the 24-inch Clark, Kodachrome 200 film, and a 1-second exposure.

Flagstaff made photoelectric measures of the pair on twenty nights and found the combined magnitude to vary between V magnitudes 6.65 and 6.79.

ADS 14238 is a closer, fainter pair that requires at least an 8-inch scope to recognize. In 1986 I found it barely resolved at 8-inches aperture with the Clark at 400x, but it was much easier when the aperture was opened up to 10- and 12-inches. The separation is widening gradually: the value listed in the table is a speckle measurement made in late 1987. A similar measurement from 1983 gives 0.61".

Another tough pair for 6-inches aperture is **ADS 14293**, which has a large magnitude difference. This summer I saw only a knot on the first diffraction ring in about position angle 200°, but not any more than that. The companion is listed as a suspected variable, but I am aware of no systematic measures looking for variability.

ADS 14359 is an excellent pair at 80x in the 6-inch. It is the northernmost star of a 7' by 5' diamond-shaped asterism aligned north-south that includes three magnitude-10 stars. I estimated a position angle of 330° and a Δm of 0.1 or less, agreeing pretty well with the catalogue data.

The relatively bright pair **ADS 14430** seemed to me to have a much larger magnitude difference than catalogued. At 165x, I estimated a value of 2.5, calling it "definitely larger than catalogues." At 165x I estimated a value of 2.5, calling it "definitely larger than 1.5 as per the *SkyCat*." A photoelectric-scanner measurement by Rakos *et al.* gives a ΔV of only 1.25. This is a pair well worth checking out for changes in relative brightness.

Probably the most difficult object on the list is **Kuiper 99**. I used the Lowell Clark at 10-inches aperture to resolve it without difficulty at 400x. The pair is composed of two late K-type dwarf stars; their yellowish orange color should be evident in larger telescopes even if they are not resolved.

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Variable Stars
A Feast of "Wonderful" Variables
by David H. Levy

"How can I find the difficult variables?" a friend once asked me. The key to locating a difficult to find variable star is to locate it once and keep observing it every night you possibly can. The star 020448 **RV Andromedae** is just such a star — a long period variable that fluctuates between magnitudes 8.7 and 11.4 over 172 days. It's also notoriously hard to find.

During one windy night in January 1977, I thought I had found RV Andromedae. But just as I moved in on the star, a gust of wind picked up the RV Andromedae chart and blew it around the campground where I was staying. The chart danced around from campsite to campsite with me following it and excusing myself as I tramped through everyone's campfires and quiet conversations. Finally, I caught the chart and continued with my observation. It's been twelve years since that night, and I recently went back to the star after a long absence. After a frustrating 20-minute search, I found RV Andromedae peeking back maliciously at magnitude 10.6.

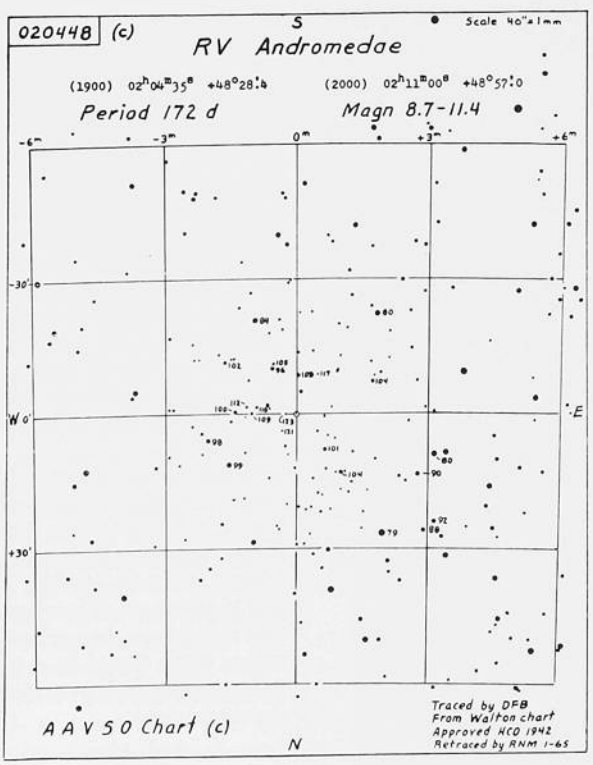
Comparing different stars of a single type makes for an interesting project this time of year because the nights tend to be consistently clear. Many long period variables are scattered across the autumn sky, so let's concentrate on this interesting variety. Like many other classes of variable stars, long period variables generally follow the behavior of the best known example, in this case **Mira** (Omicron [o] Ceti).

The variability of Mira was discovered by the Dutch pastor David Fabricius. In the weeks following August 13, 1596, he noticed this star fading until it completely disappeared. By 1609 Fabricius was observing it again; by 1639, astronomers everywhere had confirmed that this star varied in brightness. In 1662, Johannes Hevelius' *Historiola Mirae Stellae* informally assigned it the name it still uses — Mira, the Wonderful.

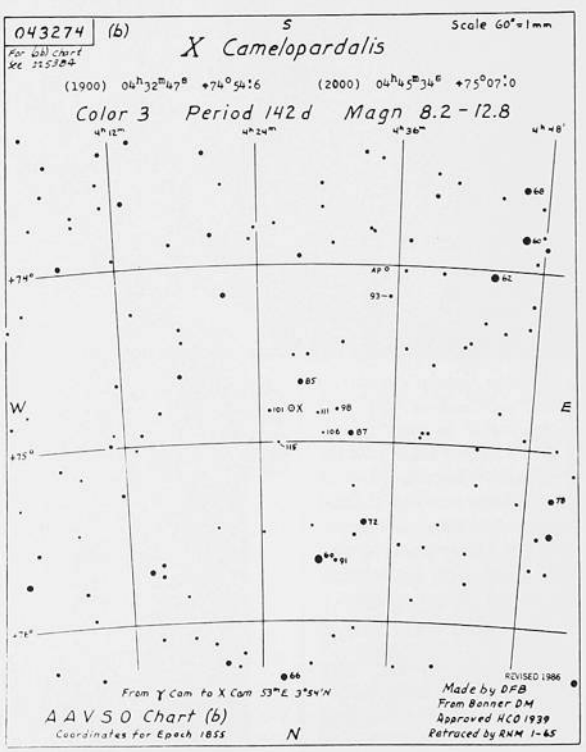
Mira stars actually change in brightness output, unlike eclipsing binaries whose light changes only because one component of a system passes in front of the other. With long period variables a physical change occurs in the star, which results in the change of brightness. These variations seem to occur in two ways. The stars expand and contract in reverse proportion to their brightness fluctuations, so at their brightest Mira stars are small and condensed. There may be more. Astronomers believe that a layer of carbon soot forms in the outer regions of Mira stars, which further decreases their brightnesses.

As you explore these stars, keep several things in mind. First, long period variables are considerably redder than most other stars nearby, and you can use their color as an aid in identification. However, a curious optical problem called the Purkinje effect is a danger: this is where red light builds up in your retina, making red stars appear brighter than they really are. Make sure you glance at the stars rather than taking prolonged stares.

One of the brightest long period stars in the autumn sky lies in Cepheus. Not far southwest of Beta Cephei, 210868 **T Cephei** may be barely visible to the naked eye at its maximum magnitude of 6.0. T Cephei fades to about magnitude 10.3 and then rises again slowly over a period of 388 days. Following the Milky Way south, Delphinus is virtually overhead in mid-northern latitudes as evening begins. This small constellation contains two interesting



Telescopic finder chart for RV Andromedae, with south at top and east at right. All charts reproduced by special permission of Janet A. Mattei, American Association of Variable Star Observers.



Telescopic finder chart for X Camelopardalis, with south at top and east at right.

stars, 201008 **R Delphini** and 203816 **S Delphini**.

According to B. B. Kukarkin's *General Catalogue of Variable Stars*, R Delphini varies over five magnitudes from 8.3 to 13.3. Its period of 285 days, almost nine months, means that between the time you begin observing it in September and the time Delphinius gets too low at the end of a year, you may catch just half of its cycle. S Delphini is easy to find, lying on a line joining Beta Delphini and Alpha Delphini. It has a shallower range than R Delphini, typically between magnitudes 8.8 and 12.0. Its period, however, is only seven days shorter than that of R Delphini. Try estimating each of these stars once per week or so, and also try to observe them under the same sky conditions.

Moving eastward to Aquarius, 204405 **T Aquarii** was the third variable star discovered in this large group of stars. Its period of 202 days means that you will be able to catch more of its cycle than that of R Delphini or S Delphini. Nearby Pegasus holds several long period variables. The star 230110 **R Pegasi** has such a long period, 378 days, that you will succeed in catching only a fraction of its variation in one season. Its range of 6.5 magnitudes (7.8 to 13.2) means that you need not estimate this star more often than once every ten days. With all Miras, however, it is a good idea to double the frequency of observation when the star is within a half magnitude of maximum or minimum.

Mira stars actually change in brightness output, unlike eclipsing binaries whose light output changes only because one component of a system passes in front of the other.

Southeast of Alpha Pegasi is 231508 **S Pegasi**, a star that varies between magnitudes 8.0 and 13.0 over a period of 319 days. Nearby 220412 **T Pegasi** is fainter at maximum than the others, ranging from 8.9 to 14.3. Its year-long period invites leisurely observing every ten days. (Incidentally, T Pegasi lies close to 220912 RU Pegasi, the autumn sky's most famous dwarf nova.)

Moving into Andromeda, we encounter 001838 **R Andromedae** some five degrees southwest of M31. This variable has the very long period of 409 days — over thirteen months. It ranges from magnitude 6.9 to 14.3. The nearby star 233335 **ST Andromedae** has a shallower range than most long period stars. Varying over only four magnitudes, from 7.7 to 11.8, its period is about 11 months or 334 days.

Finally, we should look at two stars that become easier to observe as autumn progresses. One is the circumpolar star 153378 **S Ursae Minoris**. This object is visible year round from most Northern Hemisphere latitudes as it drops from magnitude 8.4 to 12.0 and then returns in a period of 331 days.

The last variable is 043274 **X Camelopardalis**. One of the snappiest Miras around, X Cam moves through more than four magnitudes and back, from 8.1 to 12.6, in only 143 days. Changing this rapidly, X Cam is worth a look once every five to seven days. A light curve published by the American Association of Variable Star Observers shows that this star has been observed sporadically since 1904, and thoroughly since about 1913, two years after the AAVSO was founded. Since then, amateurs have watched it through at least 126 maxima. Most are sharply peaked, although in 1921 the star appeared to hold fast at maximum for at least two months. Also, X Cam showed an unusual tendency toward deep maxima followed by deeper than normal mimima. In 1957 this pattern changed briefly; the star showed a much more dramatic range from brighter than 8th magnitude to fainter than 13th.

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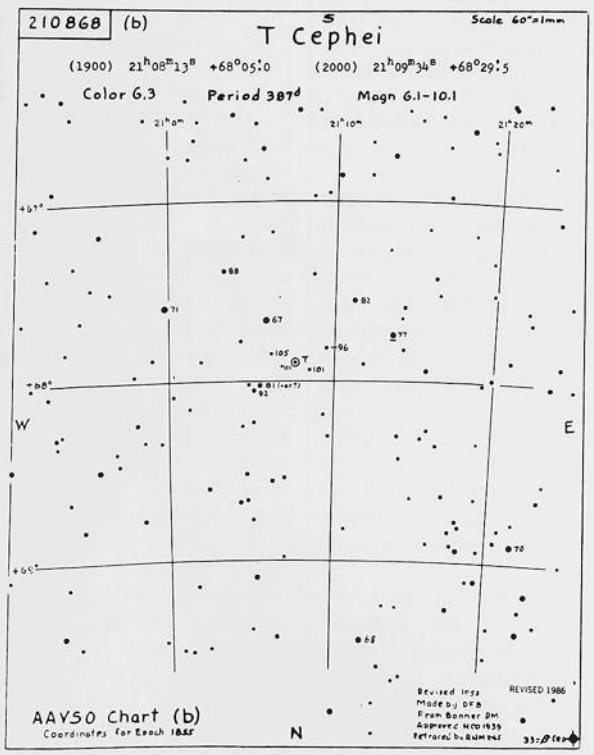
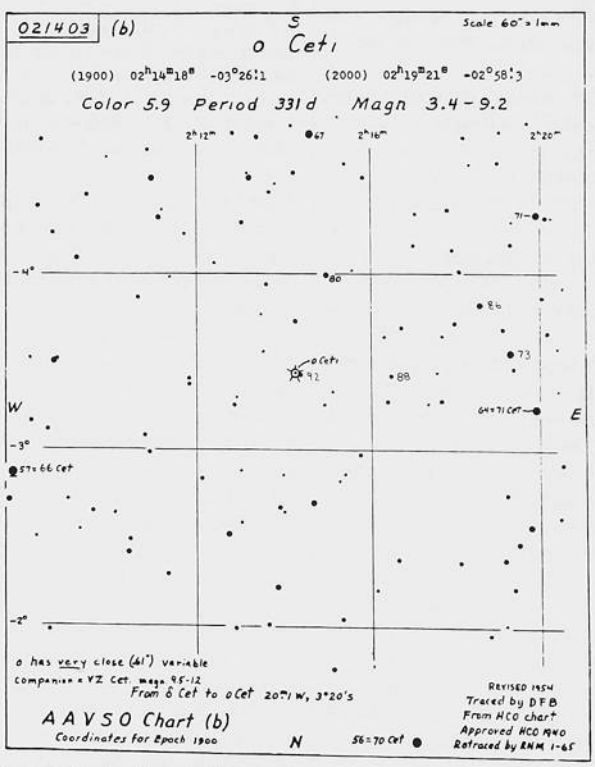


Telescopic finder chart for T Cephei, with south at top and east at right.



Telescopic finder chart for Mira (o Ceti), with south at top and east at right.

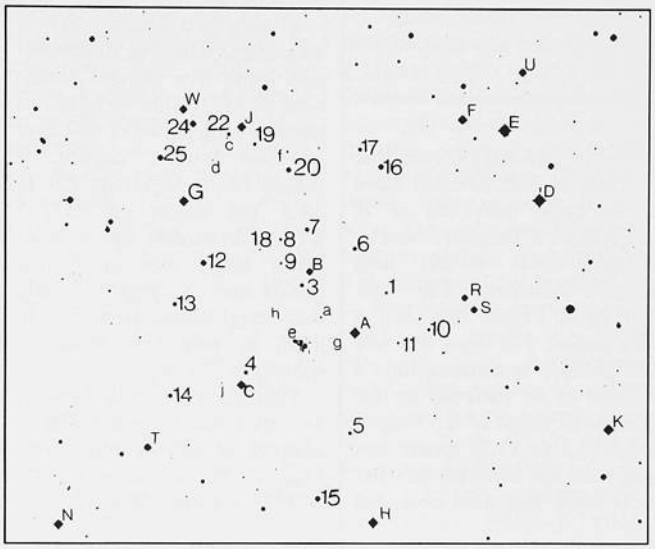
Scanning the Literature
The Latest Research News
by Brian Skiff

Two major new catalogues of galaxies have appeared in recent months. Both fill significant gaps in our knowledge of objects in the Southern Hemisphere. The first is "A Catalog of Rich Clusters of Galaxies" by George Abell (now deceased), Harold Corwin, and Ron Olowin, which appeared in the May issue of the *Astrophysical Journal Supplements* (*ApJ Suppl.* **79**:1).

Most amateurs are aware of the original "Abell catalogue" of rich galaxy clusters that was based on the Palomar Observatory *Sky Survey*, which reached to -27° declination. The present publication comprises a revised edition of the "northern" Abell catalogue and a new survey extending to the south celestial pole, based on examination of UK Schmidt southern sky survey films and plates. As before, the new catalogue includes only rich clusters with at least thirty apparent members.

The all-sky catalogue contains 4,073 clusters (up from 2,700 in the original and a supplemental list of nearly one thousand southern groups that just failed the richness test). The catalogue includes equinox 1950 and 2000 coordinates, available redshifts, and magnitudes for the first, third, and tenth brightest galaxies in each cluster. Extensive notes are also given, which describe features of most of the clusters.

The other publication is actually a hefty book: *The Surface Photometry Catalogue of the ESO-Uppsala Galaxies* by Andris Lauberts and Edwin Valentijn. This work is the result of a massive digitization of 407 blue and 407 red plates taken for the southern sky survey project with the European Southern Observatory's 1-meter Schmidt telescope in Chile. Nearly 15,500 galaxies south of -17.5° declination were scanned using a microdensitometer, which converted the photographic images into digital form for further computer processing. The digital database was combined with photoelectric measures found in the literature and new observations made by Lauberts and Valentijn. Therefore, at least one galaxy in each of the fields could serve as a standard for other galaxies on the plate.



A field identification chart for the cluster Arp-Madore 1 identifies field stars near the cluster. North is at top and east to the left, and V magnitudes are as follows: A (12.4), B (13.8), C (13.2), D (11.5), E (11.6), F (13.0), G (13.0), H (12.3), J (13.3), L (12.6), M (14.2), N (12.8), R (14.0), S (14.0), T (13.3), U (13.7), W (13.7). Numbered stars are generallly fainter yet. Adapted from Madore and Freedman, Astrophysical Journal, ***340***:*812*.

The printed version (there are more detailed magnetic tape and optical-disk versions) includes precise positions, integrated B and R magnitudes, colors, surface brightness measures, dimensions at several light levels, position angles, and more — an extremely rich source of observing material. With more than half a million numbers in the 440-page catalogue, the work may seem like ponderous reading. Lauberts and Valentijn remark that they know how fanatical astronomers can be about data like this, and they "guarantee that there are some quite exciting characters on our printed pages."

The southern sky is relatively poor in bright galaxies; their numbers do not climb significantly until beyond integrated B magnitude 13. Between 6h and 16h RA, which includes the Antlia-Hydra-Centaurus clusters and groups, there are only eighty-five objects brighter than B magnitude 12.5 (or roughly V magnitude 11.5 to 11.7) south of -30° declination. The catalogue is thought to be complete to total B magnitudes of 14.5.

The automated processing necessary for this project was not goof-proof: the Large Magellanic Cloud is listed with a magnitude of 15.46, and one magnitude 13 object in Puppis is actually a diffuse galactic nebula.

Publication of the book was subsidized by the European Southern Observatory so it is quite inexpensive. Copies of *The Surface Photometry Catalogue of the ESO-Uppsala Galaxies* are 50 deutsche marks (around $26 to $30 depending on the exchange rate). To order, ask a bank for the current exchange rate, send a check for the amount (rounded to the next highest dollar), and include a note explaining what you want. Send orders to the European Southern Observatory, Information Service, Karl-Schwarzschild-Strasse 2, D-8046 Garching bei Munchen, West Germany.

According to the June 1989 issue of *The ESO Messenger*, there are also a few copies still available of the *ESO-Uppsala Survey of the ESO(B) Atlas* by Andris Lauberts. It is a general catalogue of objects found on the "Quick Blue Survey" southern sky atlas. It contains positions, sizes, descriptions, and such of over 18,000 objects of all types, including some 16,000 galaxies. At DM 40, it is another bargain.

There are a number of other papers in the literature useful for visual and photographic observing. A detailed investigation of one of the poorer groups listed in the Abell-Corwin-Olowin catalogue was published in the same issue of the *ApJ Supplements* ("Photometric Properties of Galaxies in the Cluster DC1842-63," Marilyn Bell and Brad Whitmore, *Ap. J. Suppl.* **70**:139, May). Photometry and radial velocities are given for about 175 galaxies in this far-southern cluster. The brightest galaxy is 14765, a 10th-magnitude elliptical. The mean velocity for the group is about 4,450 km/sec, corresponding to a distance of 60 megaparsecs. A photo useful for identifying the objects at the eyepiece is included.

A summary of an ongoing survey of normal novae in the Andromeda Galaxy is given in "Fifty-two Novae in M31 Discovered and Observed at Asiago from 1971 to 1986" by a group led by Leonida Rosino (*Astronomical Journal* **97**:83, January). Plates were taken at Asiago Observatory in Italy using various instruments to search for new stars. This paper

Ident	Position	Type	Redsh	Magnitudes		SB		Colour		Dimensions			Orient		Grad	Dens	Ext
ESO	RA(1950)	type	cz	B_T	B_{25}	μ_e^B	μ_0^B	T	10″	D_e^B	D_{25}^B	D_{27}^B	a/b^0	p.a.^{0}	N_{oct}^B	N_{tot}	A_{BH}
NGC	DEC(1950)	sample	err	R_T	B_{26}	μ_e^R	μ_0^R	D_e	Δ	A_e^B	D_{26}^B	D_{90}^B	a/b^1	p.a.^{1}	N_{oct}^R	N_{Sp}	
445 0820	13 54 21	3.0	-	15.55	15.68	22.73	21.54	1.07	1.04	19.1	47	68	1.57	162.0	0.66	0.3	0.26
	-31 21.4	1 3	-	14.48	15.58	21.62	20.50	1.13	-0.12	15.1	61	48	1.30	169.3	0.82	0.3	
271 0070	13 54 25	0.0	-	15.30	15.39	22.35	21.77	1.58	1.28	28.5	62	90	3.00	53.0	0.83	0.6	0.70
	-47 02.0	2 3	-	13.72	15.34	21.10	20.49	1.21	0.40	20.7	77	58	4.29	54.8	0.73	0.3	
510 0220	13 54 25	2.0	6157	13.70	13.93	22.36	20.21	1.64	2.13	50.7	112	221	2.54	132.9	0.39	3.8	0.32
I 4350	-25 00.1	1 1	40	12.06	13.83	21.03	18.08	1.80	-0.12	34.3	162	172	2.16	134.4	0.29	2.5	
384 0180	13 54 26	1.0	4200	15.65	15.73	22.80	21.70	1.52	1.52	38.0	88	116	6.00	120.0	0.56	3.2	0.21
	-34 32.0	2 3	40	14.13	15.68	21.29	20.18	1.56	-0.11	16.8	105	82	3.65	118.8	0.77	0.6	
510 0230	13 54 27	-2.0	-	15.15	15.43	23.05	21.09	1.52	1.68	22.6	56	104	1.88	148.9	0.39	3.8	0.32
	-25 08.7	2 1	-	13.63	15.29	21.46	19.41	1.66	-0.21	18.0	80	90	1.64	150.3	0.33	2.9	
445 0830	13 54 28	6.0	-	16.06	16.19	23.20	22.59	1.52	1.55	67.6	122	174	15.00	50.0	1.01	2.9	0.22
	-27 56.9	2 3	-	14.54	16.12	21.84	21.04	1.47	-0.02	25.1	148	127	8.73	54.7	1.08	2.2	
510 0240	13 54 32	2.0	-	14.96	15.12	22.90	22.07	1.09	1.19	28.5	50	77	1.18	8.0	0.86	4.1	0.24
	-26 55.7	2 3	-	13.87	15.06	21.87	20.88	1.13	-0.05	26.3	60	57	1.18	8.0	0.96	2.9	
510 0250	13 54 43	2.0	11025	15.80	15.88	22.66	21.50	1.41	1.44	15.3	37	108	1.56	50.3	0.36	18.7	0.32
	-24 29.7	1 1	40	14.39	15.83	21.26	20.06	1.45	-0.10	13.6	45	35	1.83	45.7	0.30	-	
384 0190	13 54 44	-2.0	4211	13.66	13.93	22.58	19.91	1.56	1.60	30.5	79	176	1.20	92.1	0.35	13.0	0.21
	-33 58.5	1 2	40	12.10	13.76	20.99	18.32	1.59	-0.13	28.2	132	129	1.20	92.1	0.30	-	
271 0080	13 54 46	-2.0	2472	12.20$^-$	12.30	22.73	18.81	1.62	1.67	60.3	221	305	1.62	4.0	0.30	1.3	0.33
N 5365	-43 41.2	1 1	45	10.57$^-$	12.23	21.06	17.14	1.69	-0.06	44.7	269	216	1.14	173.1	0.23	1.0	
510 0260	13 54 46	9.0	-	15.49	16.29	25.09	23.36	0.49	0.85	60.3	58	-	1.65	20.8	0.78	2.9	0.30
	-25 32.9	2 2	-	15.00	15.88	24.49	22.50	0.72	-0.23	48.4	90	135	1.65	20.8	0.66	1.9	
325 0371	13 54 47	3.6	-	16.63^0	16.63	-	21.59	1.28	1.26	< 10	20	-	3.34	125.2	3.00	-	0.22
	-38 48.1	0 4	-	15.35	16.63	-	20.33	-	-	18.8	21	15	3.34	125.2	3.00	-	
325 0370	13 54 47	0.2	10810	15.91^0	16.03	-	21.34	1.28	1.35	< 10	27	45	1.16	119.9	0.54	0.6	0.22
	-38 47.9	1 4	119	14.63	15.96	-	19.99	-	-	17.0	36	28	1.16	119.9	0.54	0.6	
221 0190	13 54 51	7.4	-	16.23	16.51	23.86	22.58	1.15	1.01	27.5	46	76	2.00	148.0	0.91	2.2	0.72
	-47 48.4	1 4	-	15.08	16.33	22.95	21.57	1.01	0.12	19.7	62	60	1.85	148.9	1.21	1.6	

Part of a sample page from The Surface Photometry Catalogue of the ESO-Uppsala Galaxies *demonstrates the richness of its information. Authors Lauberts and Valentijn "guarantee that there are some quite exciting characters on our printed pages."*

includes B (blue) magnitude sequences in several fields around the galaxy that are useful for calibration.

Novae occur at the rate of two or three per month in this galaxy and peak at magnitude 16, a fact that makes them relatively easy to find photographically using amateur equipment, and indeed several have been. Why don't you try it this autumn and winter?

Another batch of magnitude sequences around galaxies can be found in "UBVRI Photoelectric Photometry in the Fields of Fifteen Active Galaxies" by Mario Hamuy and Jose Maza (*AJ*(b) 97(t):720, March). Measures in five colors of nearly 120 stars in fifteen fields around Seyferts, BL Lacertae objects, and quasars in the equatorial and southern sky are presented. The stars lie in the range from V magnitude 8.5 down to about 15.5 and are identified on excellent photographic finder charts of each field.

In the star cluster department, an interesting paper has appeared about Messier 71 ("Star Counts in the Globular Cluster M71" by Harvey Richer and Greg Fahlman, *ApJ* **339**:178, April 1). Star counts were carried out on four V-band CCD frames that reach down to magnitude 24; over 10,000 stars were found using the DAOPHOT computer photometry package. The frames cover incompletely an area centered on the cluster and out to about 3.5' radius. Although a total diameter cannot be explicitly derived from the data, the counts per magnitude bin are tabulated after making corrections for incompleteness and for the rich Milky Way background.

Range in V	Counts	+/- error
12 - 13	8.7	4.2
13 - 14	17.8	5.6
14 - 15	98.4	10.2
15 - 16	99.0	11.5
16 - 17	150.4	17.8
17 - 18	1152.3	36.1

The counts make big jumps between magnitude 14 and 15 and between 17 and 18. These jumps reflect the increase in stars at the horizontal branch (V = 14.4) and at magnitude 18, the magnitude point for main-sequence stars.

The faint southern globular AM-1 has been a difficult nut to crack. A new photometric study, the third of this object, provides state-of-the-art information about AM-1 ("Photographic, Near Infrared, and CCD Photometry of the Distant Globular Cluster AM-1" by Barry Madore and Wendy Freedman, *AJ* **340**:842, May 15). This paper provides a photoelectric sequence in the field between magnitude 11.5 and 18.2 with an excellent finder chart that will be useful for locating this elusive object visually. From the data in the paper, the authors derived a distance of 120 kiloparsecs, making it among the most distant objects in the Galaxy, indeed, twice the distance of the Magellanic Clouds! The cluster's brightest stars are only V magnitude 18.0, with the horizontal branch at about magnitude 21.0. The total V magnitude is only 15.0, with a tidal diameter of 2.3'.

Careful photographic photometry of a cluster previously dubbed "the southern image of M11" is presented in "BV Photographic Photometry of the Southern Open Cluster NGC 6259" by a group led by Barbara Anthony-Twarog (*A.J.* **97**:1048, April). This cluster lies in southern Scorpius and is a fine sight from good locations in the southern United States. The brightest members of the cluster are V magnitude 12.0 to 12.5 and include several red giants. There are about eighty members brighter than magnitude 15.0. The astronomers derive a distance of 2,000 parsecs and an age of 70 million years; the cluster is dimmed by around three magnitudes in the visual. The article includes an identification chart of the measured stars.

The latest batch of speckle interferometry of double stars by Harold McAlister and his group is also out ("ICCD Speckle Observations of Binary Stars. IV. Measurements During 1986-1988 From the Kitt Peak 4-m Telescope," *A.J.* **97**: 510, February). Measures of one thousand very close systems are given, but there are also many reasonably wide visual objects wider than 0.5" accessible in amateur instruments.

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All ***GALAXY OPTICS ULTIMATE IMAGE™ MIRRORS*** are thoroughly tested throughout each stage of completion and are totally hand-figured and null tested to assure you of a professional quality paraboloidal optic.

GALAXY'S ULTIMATE IMAGE™ full thickness (1:6) and lightweight mirrors (2.00") are made from Precision annealed *molded* Pyrex mirror blanks and are available with a choice of two outstanding reflective coatings.

COATING #1: 88% Reflectivity - Aluminized and quartz overcoated
COATING #2: 96% Reflectivity - Broadband multilayer dielectric coating over aluminum

FULL THICKNESS 1:6 OPTICS

MIRROR	COATING #1	COATING #2
10"	$ 375	$ 425
12.5"	525	600
16.0"	1700	1950
18.0"	2300	★
20.0"	3400	★

LIGHTWEIGHT 2.00" THICKNESS OPTICS

MIRROR	COATING #1	COATING #2
14.5"	$ 850	1050
16.0"	1100	1350
18.0"	1300	★
20.0"	1650	★
22.0"	2970	★
25.0"	4950	★

GALAXY'S ultra-lightweight mirrors (1.6") are made from fine annealed Pyrex mirror blanks and are manufactured to the same specifications as our 1:6 mirrors.

ULTRA-LIGHTWEIGHT 1.6" OPTICS

MIRROR	COATING #1	COATING #2
14.5"	$ 725	$ 925
16.0"	950	1200
18.0"	1100	★
20.0"	1400	★
22.0"	2450	★

★ Enhanced aluminum coatings by special request only.

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1/10 WAVE, 20/10 SURFACE QUALITY - GUARANTEED

MINOR AXIS	COATING #1	COATING #2
2.1"	$ 75	$100
2.6"	75	100
3.1"	95	120
3.5"	265	300
4.0"	285	325
5.0"	425	475

All mirrors are available in many popular focal ratios. Full thickness (1:6) and ultra-lightweight Zerodur® Optics available. Mirror refiguring services, write for quotation. For a complete product catalog mail $1.00 to:

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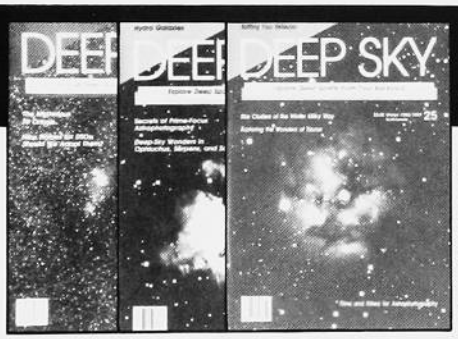

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Sketching Details in Galaxies, Observing Galaxy Clusters in Leo and Coma Berenices, Deep-Sky Objects in Centaurus

DEEP SKY 13
The Bright Star Clusters of Canis Major, Deep-Sky Objects in Auriga and Gemini, How to Photograph Star Clusters

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Deep Sky Objects Along Halley's Path, Visiting Lowell Observatory, The IC 4329 Galaxy Group

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Summer's Multitude of Planetaries, The Central Stars of Planetary Nebulae, Observing Planetaries from the City

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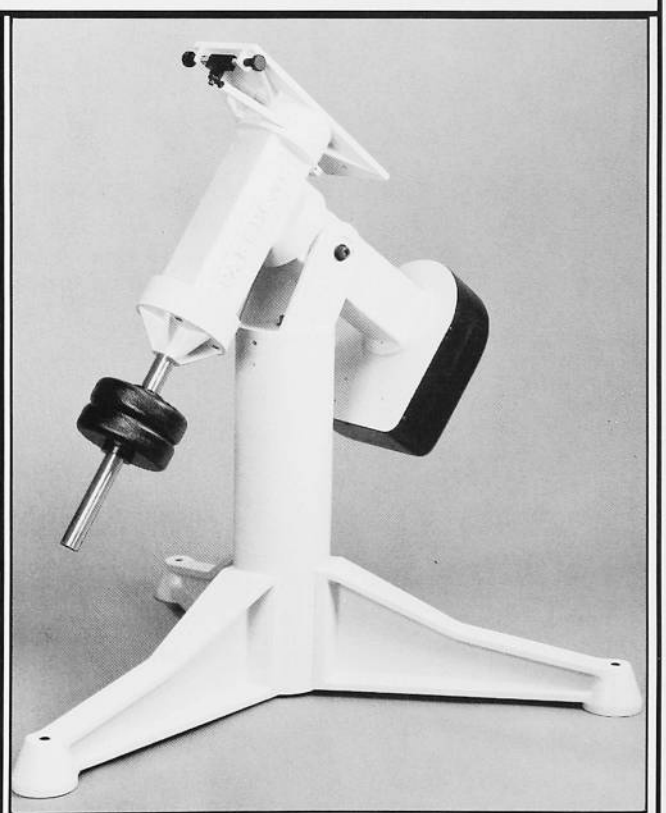

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Computer-Controlled Digital Setting Circles, from $498

Incredibly Smart!
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- Digital right ascension readout to 1 minute of R.A.
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- Polar alignment **not required!**
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- Works for alt-azimuth **and** equatorial mounts

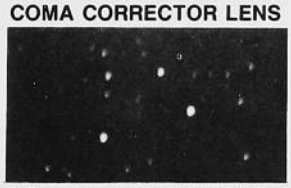
LUMICON Sky Vector™ (state scope) **$498**
Sky Vector™ Kit (you supply hardware) **$469**
Pair digital shaft encoders (for 2nd scope) **$135**

LUMICON 50mm, 80mm SUPER-FINDER™

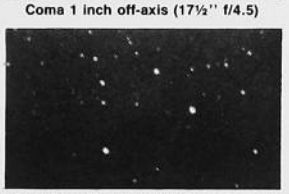
Visual Astronomers perfer the LUMICON 80mm SUPER-FINDER™, since hundreds of deep-sky objects, including most Messier objects, are visible directly. SUPER-FINDERS also make nice small portable telescopes. 80mm aperture, F = 300mm coated achromat. The deluxe SUPER-FINDER uses an 80mm, F = 500mm air spaced achromat.

1¼" 50mm Finderscope **$59.50**, right-angle **$89.50**
1¼" straight-thru 80mm SUPER-FINDER **$169**
1¼" right-angle version, w/star diagonal **$195**
2" right-angle version, non-rotating focuser **$199**
1¼" Deluxe right-angle Super-Finder **$279**
2" Deluxe right-angle Super-Finder **$309**
25mm Cross-hair 1¼" eyepiece (12X) **$29**
1¼" Star Diag. . . **$32**, 2" Star Diag., silver, . . **$145**
1¼" Amici Prism diag. for correct left-right views **$59.50**

COMA CORRECTOR LENS



Coma 1 inch off-axis (17½" f/4.5)



Same Field with LUMICON coma corrector lens; note smaller, more numerous stars.

This computer-designed LUMICON 2" lens reduces coma and flattens the field for both viewing and photography. It threads into LUMICON 2" EASY-GUIDERS for effortless installation. This lens is optimized for f/4.5 and reduces aberrations for f/3.5 to f/5 Newtonians. Off-axis images are much smaller, making off-axis guiding far easier and yielding round pinpoint star images in photos. Since star images are sharp over a full 2¼" circle, you can use medium format cameras in addition to 35mm cameras. This zero power lens does not change image scale nor shift focus, and all lens surfaces are multi-coated for highest efficiency. Although designed for photography you may also use this lens to improve image quality in wide-field viewing with low power eyepieces.

LUMICON Coma Corrector/Field Flattener
2" lens **$285.00**
Extension tube for viewing **$26**
2" Easy-Guider™ (state camera) . . **$169.50**

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NEW! ENCHANCED SILVER DIAGONAL MIRRORS BOOST TELESCOPE PERFORMANCE

LUMICON 1.3" & 3.1" enhanced silver diagonal mirrors & 2" star diagonal.
The new LUMICON diagonal mirrors have a special enhanced silver coating with a protective overcoating for long life. Visible reflectivity is 98-99% compared to 86-89% for standard aluminum coated mirrors. The extra 10-12% transmission is like adding an inch of aperture! The substrate is fine annealed Pyrex flat to 1/8 wave.

1.32" **$29.95** 1.52" **$34.50** 1.83" **$39.50**
2.14" **$49.50** 2.60" **$65.00** 3.10" **$89.50**
4.25" **$149.50**

ENHANCED SILVER STAR DIAGONAL

90° star diagonals with above enhanced silver mirrors in a CNC machined black anodized aluminum body. Performance far exceeds prism diagonals.
1¼" (1.32" mirror) **$89.50**
2" (1.83" mirror)(see photo above) . . **$145.00**

OXYGEN-III FILTER

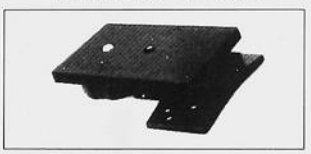
Helix Nebula, NGC 7293 in Aquarius. Bright and easy with Lumicon Oxygen-III Filter.

The ultimate in filter performance! The Lumicon Oxygen-III Filter has a contrast twice as high as the high performance Lumicon UHC Filter™ Use the Oxygen-III Filter for observing the very faintest planetary and diffuse emission nebulae. Also gives incredible views of bright nebulae (like M-27, M-17, etc.) from urban locations. Bandpass is 11nm, transmission is 90% for both O-III lines at 496nm and 501nm.

Filter Type	1¼"	48mm
Lumicon Oxygen-III	$99.50	$199.50
Lumicon UHC	$99.50	$199.50
Lumicon Deep-Sky	$79.50	$119.50
Set UHC and Oxygen-III	$190.00	$380.00

NOTE: The Oxygen-III Filter is not a substitute, but a compliment to the UHC Filter. **1 year guarantee:** You must see nebulae with the O-III filter that are **invisible** without a filter.

NEW ADJUSTABLE PIGGYBACK MOUNT



LUMICON has just designed a new adjustable piggyback mount ideal for all telescopes of 8-14" aperture. It has **both** vertical and sideways adjustment to allow optical alignment. It was designed to allow mounting of the LUMICON SUPER-FINDER on C-8, C-14, etc., but is ideal for any telephoto lenses or small telescopes.

Deluxe Piggyback Mount $45.00
(State Telescope Type)
LUMICON 12x80mm SUPER-FINDER . $170

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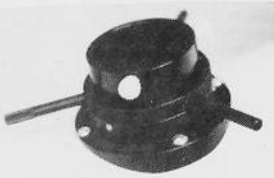

LUMICON® DELUXE NON-ROTATING HELICAL FOCUSER on a 6" telescope.
LUMICON now offers 3 different low-profile helical focusers. They stand only 1¼-1½" above the telescope tube. Use the 1¼" or 2" versions for viewing. Use the 2" non-rotating focuser for convenient photography with the LUMICON 2" EASY-GUIDER™.
Select your desired base-plate shape!
Flat, 7" OD, 9½" OD, 12½" OD, 16" OD, 21" OD, SUPER-FINDER base plate.
LUMICON 1¼" Helical Focuser $49.50
LUMICON 2" Helical Focuser $59.50
LUMICON Non-rotating Helical Focuser $79.50
3 handles (see photo) for non-rotat. focuser **$12.95**
2"/1¼" adapter w/48mm filter threads . . **$20.00**
2" LUMICON EASY-GUIDER $169.50

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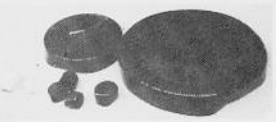

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2"	2/$2	12½", 12⅞"*	$15
3½", 4½"	$5	16"*	$20
5½"	$6	19" (DS-16)	$27

*Fits Odyssey

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LUMICON HYPER-KITS™ yield 3-15X film speed gain in long exposures. They are safe & simple to use. Easy HYPER-KIT includes a chamber with all controls and fittings, thermometer, a refillable cylinder of non-flammable forming gas & hand-operated vacuum pump.

†U.S. Patent 4,473,636

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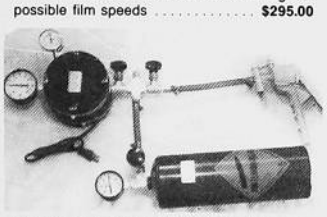

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Temperature controller for any HYPER-KIT **$59.50**

Electric Vacuum Pump **$280.00**

GUIDE OFF-AXIS FOR LOVELY ASTROPHOTOS

All **LUMICON EASY-GUIDER™** off-axis guiders† have both radial and 360° rotational adjustments for 5X easier guide-star selection, use 48mm filters, 360° camera rotation, large prisms of bright guide-starts. *Specify Camera and Telescope type.*
U.S. Patent #4,448,500

NEWTONIAN EASY-GUIDER™

Full aperture. Installs in secs. Specify 2" or 1¼".

NEWTONIAN EASY-GUIDER **$169.50**
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For C-8, Meade 2080, Dynamax-8. Includes 50mm achromatic lens for f/5.8 operation —3X shorter exposures! **Superb rich field viewing, too!**
CASSEGRAIN EASY-GUIDER **$225.00**
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For Celestron-11, C-14, and the 10" Meade 2120. Includes 80mm clear aperture achromatic lens for edge-to-edge illumination & pin-point star images. F-ratio adjustable f/4-f/11. **Also yields unmatched Rich-Field viewing.**

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1. Illuminated reticle eyepiece **$79.50**
Lumicon 12mm eyepiece system has adjustable L.E.D. illumination, dual crosslines, battery pack.

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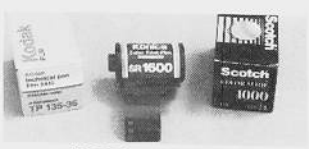

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